

# SOUTHERN FIELD CROPS

*Revised Edition*



DUGGAR

◀ Rural Textbook Series ▶







# The Rural Textbook Series

EDITED BY L. H. BAILEY

## SOUTHERN FIELD CROPS

## The Rural Textbook Series

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# SOUTHERN FIELD CROPS

REVISED EDITION

BY

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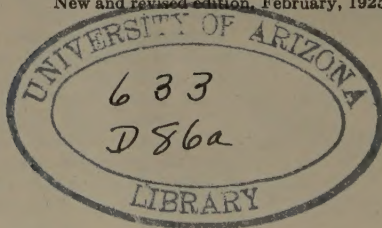
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TO  
MY PARENTS  
DR. REUBEN HENRY DUGGAR  
AND  
MARGARET LOUISA (MINGE) DUGGAR  
THIS BOOK  
IS AFFECTIONATELY INSCRIBED  
AS A SLIGHT TOKEN OF APPRECIATION OF  
THEIR HIGH IDEALS AND CAREFUL  
PARENTAL TRAINING

59952



## PREFACE

About thirteen years ago the author's *Southern Field Crops* was published. This was the first systematic American treatment of field crops from a regional standpoint. Its limited geographical field permitted a practical as well as a pedagogical form of presentation. Doubtless it is largely to these features that this book owes its extensive use as a text in vocational schools, high schools, and colleges in most of the Southern States.

The present volume constitutes primarily a rewriting of that earlier book so as to incorporate the best results of recent progress in agricultural research and the most approved recent practices as applied to the Southern States. In probably no other part of our country is there such urgency for farmers to keep their practice abreast of scientific research and adapted to changing rural conditions.

Chief among these shifting conditions is the widened area dominated by the Mexican cotton-boll weevil, with the consequent need for modifications of farming methods that are scarcely short of revolutionary. The author has had in mind also, without obtrusive prophecy, to anticipate even further changes that seem to be advisable when a more recent invader, the Mexican bean beetle, shall have covered most of the country and shall have profoundly affected the Southern farmer's choice of leguminous plants for soil improvement and for forage.

As in the earlier volume, the author's specific aims have been simplicity of statement and pedagogical form. First

consideration has been the needs of the agricultural teacher and student in vocational and high schools. Regard has been had also to the use of selected parts of this book as the basis for unit and extension courses either for mature farmers or for young persons. The Laboratory Exercises, together with seasonal selections from the text, may be made an indispensable part of home projects in vocational schools. Some condensation of the text has been found expedient.

For the college instructor who may desire to build his lectures on the foundation laid by a simple printed outline of the subject, the references to agricultural books and pamphlets have been extended and brought up to date and Advanced Topics have been systematically suggested for development by lectures or assigned reading and laboratory practice. The lists of references are selective rather than exhaustive.

The student in high school, as well as the collegian, will be served by the inclusion, for reference, of the scientific names of crop plants and their insect and fungous enemies. Such terms are needed in looking further into the literature of the subject as well as useful in other ways.

Credit is given and obligation is here expressed to these institutions and individuals that have kindly furnished certain of the pictures here employed.

J. F. DUGGAR.

AUBURN, ALABAMA.

October 1, 1924.

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# SOUTHERN FIELD CROPS



PART I  
THE CEREAL GRAINS



# SOUTHERN FIELD CROPS

## CHAPTER I

### OATS (*Avena sativa*)

The oat plant is included in the great family of the grasses (Gramineæ), as are all the grains. It came into use at a later date than did wheat and barley.

The seed, or grain, of oats is used chiefly as food for horses. It is also employed, in the form of oatmeal and other cereal dishes, as human food. The oat plant is useful for hay and for pasturage. Its straw is utilized as feed and bedding for animals and as packing material.

### STRUCTURE

**1. Roots.** The oat, like the other grains, is a fibrous-rooted plant having no taproot. The crown from which the main stems originate is usually within about an inch of the surface of the ground.

**2. Stems.** The stems of the oat plant originate in the same way as those of the wheat, each as a developed bud or branch from an older stem. At each underground *node*, or joint, of every stem a bud may develop into another stalk and its lower nodes in turn may send out additional shoots. Hence a single plant may bear an indefinite number of stems, the usual number, however, being two to six. A large number is formed by thin sowing and by abun-

dance of moisture and plant food or by hilling up earth around the lower nodes. The conditions that hinder tillering, or branching, are thick sowing, late sowing, and deficiency of moisture or plant food.

**3. Leaves.** The leaf blade of the oat is wider than that of wheat or rye. At the junction of the leaf blade and sheath



Fig. 1. — Part of an oat plant

Note the absence of clasps where leaf blade and sheath join.

there are no clasps or *auricles* (Fig. 1), their absence serving to distinguish the young oat plant from that of any other small grain.

**4. Pollination.** The oat in nature is self-pollinated; hence there is practically no danger of crossing of different varieties. Several varieties may be sown in adjacent fields, if care is taken to prevent mixing by mechanical means, as in harvesting and threshing.

**5. Panicle and spikelets.**

The grain-bearing part of the plant, though usually called a head, is really a *panicle*, or widely branched terminal part of the stem (Fig. 2). The branches of the head originate at the upper nodes of the stem, several usually springing from each node. Each branch may bear a single *spikelet* (that is, a group of grains) or several spikelets.

Each spikelet (Fig. 3) consists of two or more flowers, of which usually only two develop into perfect grains.

Those that usually develop are the two grains nearest to the branch, the nearer or lower one being the larger.

**6. Grain.** The valuable part of each grain consists of a nearly cylindrical kernel that can be pinched out of its lightly inclosing hull. The latter is made up (1) of a nearly transparent *palea* covering the kernel on its inner, or crease, side and (2) of a stiff hull, or *lemma*, which covers most of the grain. It is the lemma that determines the color of the threshed oats and from the back of which grow beards in bearded, or *awned*, varieties.



Fig. 3. — Oat spikelet in bloom

Note two outer pieces of chaff inclosing two flowers, each containing three anthers (pollen cases) and two plumelike stigmas.

price of oats. The percentage of germination is sometimes lowered when oats are stacked or bulked while too damp.

In most states the legal weight of a bushel of oats is thirty-two pounds. Oat grains germinate

well even when two or three years old. The hull averages about 30 per cent of the total weight of the grain, but the percentage varies in different varieties and seasons. A measured bushel varies in weight according to the variety and the season and usually ranges between thirty and thirty-six pounds. Plumpness and absence of weather stain largely determine the grade and selling



Courtesy Cal. Experiment Station

Fig. 2. — A panicle of Red oats

## COMPOSITION

**7. Analysis.** According to Hunt (*Cereals in America*) the average of American analyses is as follows:

TABLE I. COMPOSITION OF OATS

	OAT GRAIN (Per cent)	OAT KERNEL (Per cent)	OAT STRAW (Per cent)	OAT HAY CUT IN MILK (Per cent)	OAT HULLS (Per cent)
Water . . . . .	11.0	7.9	9.2	15.0	7.3
Ash . . . . .	3.0	2.0	5.1	5.2	6.7
Protein . . . . .	11.8	14.7	4.0	9.3	3.3
Crude fiber . . . . .	9.5	0.9	37.0	29.2	29.7
Nitrogen-free extract . . . . .	59.7	67.4	42.4	39.0	52.0
Fat . . . . .	5.0	7.1	2.3	2.3	1.0

**8. Draft on soil fertility.** A crop of 40 bushels of oats with the accompanying quantity of straw removes the following amounts of nitrogen, phosphoric acid, and potash.

TABLE II. PLANT FOOD REMOVED FROM THE SOIL  
BY AN OAT CROP

	NITROGEN	PHOSPHORIC ACID	POTASH
	(Per cent)	(Per cent)	(Per cent)
Oat grains with hulls . . . . .	1.76	0.59	0.48
Oat straw . . . . .	0.56	0.28	1.62
	(Pounds)	(Pounds)	(Pounds)
Oat grain removes in a crop of 40 bu. (1280 lb.) . . . . .	22.53	8.83	6.14
Oat straw (1500 lb.) removes . . . . .	8.40	4.20	24.30
Total crop of 40 bu. and 1500 lb. of straw removes . . . . .	30.93	13.03	30.44

The greater part of the nitrogen and of the phosphoric acid is removed by the grain, while most of the potash is contained in the straw. The straw should be returned to the land in the form of stable manure after having been used either as feed or as bedding.

## VARIETIES

**9. Types of Southern oats.** In the Southern States the varieties of oats chiefly grown are (1) Red rustproof, (2) Fulghum, (3) Burt, and (4) Winter turf. Among the subvarieties or selections of the Red rustproof types are the Appler (Fig. 8) and Bancroft.

**10. Red rustproof oats.** This variety (Fig. 4), including its selections, is the most popular type of oats from North Carolina to Texas. Its three distinguishing characters are the following: (1) The base of the upper, or smaller, grain is prolonged into a sharp tip because this grain retains its short supporting stem; (2) at the base of the lower, or larger, grain before threshing is a bunch of fine hairs, or bristles, longer than in most other varieties; and (3) the grain is plump and brownish to reddish in color.

Both grains of many spikelets are supplied with a stout beard.

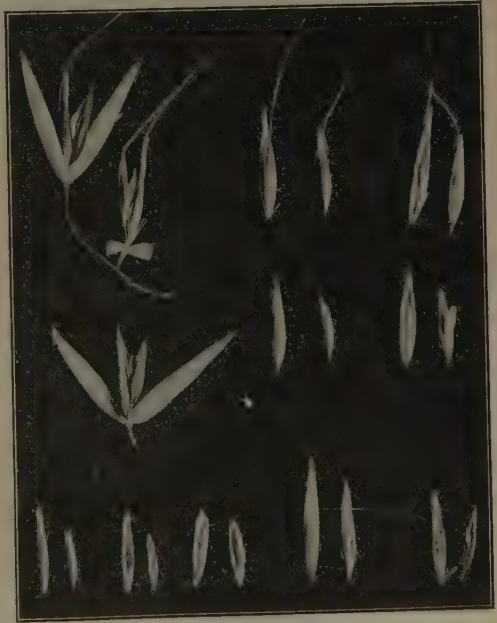


Fig. 4. — Grains and spikelets of oats

Top row, Red rustproof variety; middle row, Fulghum; bottom row (right), four grains of Burt; (left) six grains of unacclimatized feed oats.

**11. Fulghum oats.** This is a beardless variety (Fig. 4), a week or two earlier in maturity than Red oats, which it otherwise resembles. It is about as early as Burt, is hardier, and has plumper grains.

Fulghum and Red rustproof varieties have stouter, shorter straw than other kinds grown in the South and are, therefore, less liable to fall, or *lodge*, near the time of maturity (Fig. 13).

**12. Burt oats.** This variety (Fig. 4) has slender grains of a grayish or light-dun color, both the upper and lower seed in the spikelet usually bearing a slender beard. It is a week or two earlier than Red rustproof varieties sown at the same time. It is more sensitive to cold than Red oats and is essentially a variety for sowing after Christmas, except in the southern part of the Cotton Belt.

**13. Winter turf oats.** This is the hardiest of the varieties and has been known to survive the winters a little higher than the latitude of northern Virginia. It is practically safe against winter killing throughout the Cotton Belt; yet it is not so hardy as wheat.

The grain is slender and of a gray or light-dun color. Usually there are beards on one grain in each spikelet. This oat branches, or *stools*, freely, thus making it especially valuable for pasturing and winning for it the name of "grazing oats." The straw is tall and slender.

This variety ripens about two weeks later than Red rustproof oats sown at the same time. It is much more susceptible to rust; and on poor land or with unfavorable seasons it often fails to produce plump, well-filled grains. Its best place is in the region just north of the Cotton Belt.

Turf oats are unsuitable for sowing after Christmas. This variety requires earlier planting in the fall than Red oats.

**14. Improvement of varieties.** Even in unmixed varieties there are numerous strains, or elementary species, differing slightly in appearance and still more in productiveness. A variety may be purified, made more uniform, and increased in productiveness by planting in separate rows the seed from each of a number of selected plants and multiplying only the oats grown on the best and most uniform rows. In the Burt and even in the Fulghum and Red varieties, breeding is needed for added resistance to cold, for greater uniformity, and for increased yield. Apparently for fall sowing it is best to use seed from a strain that has become adapted to such practice.

#### CLIMATE, SOILS, AND FERTILIZATION

**15. Climate.** The oat plant is most at home in a cool, moist climate. Yet in the Southern States, with a moist but hot climate, it is successfully cultivated. In the South climate is most important in determining whether Red rustproof varieties should be sown in the fall or after mid-winter.

That part of the South in which by far the greater part of the crop of Red rustproof oats is sown in the fall lies chiefly south of a line drawn through Birmingham in Alabama, Atlanta in Georgia, Charlotte in North Carolina, and Norfolk in Virginia. Yet, experience shows that it is profitable to sow Red rustproof oats in the fall considerably northward of this line, though at the risk of more frequent failures from winter killing. Even in the northern third of the Gulf states this class of oats, when sown in the fall, is not seriously injured by cold in one winter out of three. Since two crops of fall-sown oats usually yield more than three crops of oats sown after Christmas, fall sowing should be more generally practiced. North of the

line indicated above, Turf oats are hardy in most winters at least as far northward as Maryland.

**16. Soils.** The oat is adapted to a wider range of soils than is wheat. In fact, it may be grown on almost any soil on which other ordinary field crops succeed. Nevertheless, oats thrive on a moderately rich soil. Fertilizer is especially important when sowing is done after Christmas. The low average yield of oats is largely due to the fact that this grain is often sown on land too poor for other profitable use.

**17. Place in the rotation.** The usual position of the oat crop in a rotation in the Cotton Belt is immediately after corn, the oats being followed by cowpeas the same year and the cowpeas being followed by cotton the next year. This is the logical practice for fall-sown oats, since the corn crop can be removed in October in time for the sowing of oats, while cotton is usually not removed in time for the largest yield of fall-sown oats. However, in regions where spring sowing of oats is practiced, this crop may just as well follow cotton as corn. Oats and other small grains should be followed the same season by cowpeas or other legumes.

**18. Fertilization.** Experiments have shown that it pays to fertilize oats growing on medium or poor lands (Fig. 5). The most universal need of oats on the average soils of the Cotton Belt is for nitrogen. Since the oat makes its growth in the cooler part of the year when vegetable matter does not rapidly nitrify, or become available as plant food, the best form of nitrogenous fertilizer is one which immediately becomes available, such as nitrate of soda.

Tests have shown that it is usually profitable to apply any amount of nitrate of soda between 40 and 160 pounds per acre. About 80 pounds per acre is a common amount. The lumps should be crushed carefully and the fertilizer

sown broadcast as a top dressing at least two months before the average date of harvest. As a rule, the first half of March is a suitable time for applying nitrate of soda to fall-sown oats, and the latter half of the month for spring-sown oats.

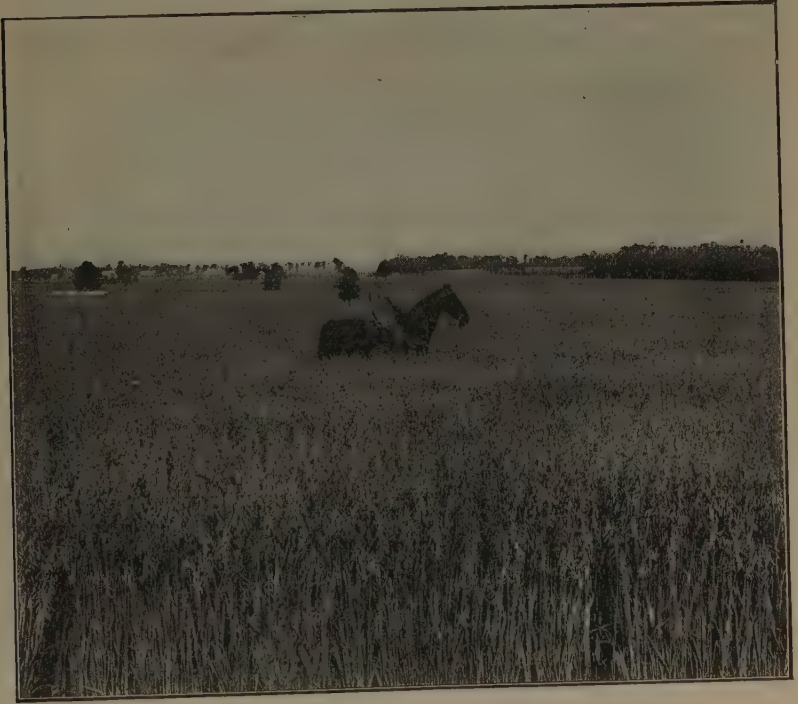


Fig. 5. — A field of oats in Georgia

Acid phosphate is often used at the rate of 100 to 200 pounds per acre at the time of sowing. It may be run through the fertilizer attachment of the grain drill, as its contact with the seed will not injure germination. However, it would not be safe thus to sow through the grain drill and with the seed any considerable amount of cot-

ton seed meal, or other nitrogenous fertilizer, or of potash salts.

While some sandy soils may require for the maximum growth of oats a small amount of potash, its use is generally unnecessary.

**19. Preparation of land and sowing.** The usual preparation of the land for oats is poorer than for most other



*Courtesy International Harvester Co.*

Fig. 6. — A grain drill for sowing oats and other small grains

crops. The fields should be well plowed, promptly harrowed, and the seed planted with a grain drill (Fig. 6). If this machine is not available, the seed may be sown broadcast from the hand or by using a small hand seeder or from a large seeder attached to the back part of a wagon body and driven by a sprocket chain which engages a sprocket

wheel bolted to one of the hind wheels of the wagon. Covering of oats sowed on plowed ground is usually best done with a disc or other deep-working harrow. This is better than merely turning under the seed sown on unplowed land.

Drilling of any kind of grain usually affords a larger yield than broadcast sowing. This is chiefly because the former places the seed more uniformly at the depth desired, thus promoting completeness and uniformity of germination. Drilling leaves the plants in a very shallow depression, which affords a slight degree of protection from cold and against *heaving*, or lifting, when the ground freezes.

**20. Open-furrow method of drilling.** In the northern part of the Cotton Belt, oats may be sown more safely in the fall by this method (Fig. 7) than otherwise. It consists in sowing the seed in the bottom of a deep furrow, or trench, a one-horse planter or a special deep-furrow grain drill of larger size being used. The seeds are barely covered by the small amount of soil which falls into the trench as the planter passes along. Therefore, the plants grow from the bottom of a rather deep furrow which remains unfilled throughout the winter. Here they are somewhat shielded from cold and greatly protected from heaving, since the soil and the plants in the bottom of a furrow are not easily lifted by alternate freezing and thawing.

These deep furrows are 18 to 24 inches apart. Fertilizer is drilled in with the seed.

An incidental advantage of the open-furrow method is that it permits thorough harrowing in early spring. This method is not adapted to very stiff or poorly drained soil, and it is usually a slow operation.

**21. Prevention of winter killing.** Oats are more frequently killed by the heaving of the soil and of the young plants when the ground freezes than from the direct effects

of low temperatures. Heaving is due to the expansion in freezing of the water in the soil. Everyone has noticed on a frosty morning the little icicles projected upward from a spot of wet clayey land. Often these icicles lift



*Courtesy Georgia Experiment Station*

Fig. 7. — Oats sown in open furrows

on their summits particles of soil. By this same process of expansion of soil moisture in freezing, young plants are lifted. This heaving is worst in soils that contain the most water; that is, in clay spots and where the drainage is poor.

Means of decreasing winter killing of oats are: (1) plant-

ing in depressions or unfilled furrows (the open-furrow system); (2) improved drainage; (3) selection of hardy varieties, or strains; (4) the use of the roller to settle the lifted plants into closer contact with the soil.

**22. Quantity of seed.** On account of the ability of the oat plant to throw out an indefinite number of shoots, or *culms*, and thus to utilize whatever space may be available, the thickness of sowing does not directly determine the rate of yield. From 4 to 16 pecks to the acre may be taken as the extreme limits. The quantity of seed usually advisable for broadcast sowing is between  $1\frac{1}{2}$  and 3 bushels per acre. By the use of the grain drill, this may be reduced by about half a bushel per acre, and the open-furrow method makes possible an even greater reduction. The earlier the date of sowing and the more complete the preparation of the land, the smaller may be the quantity of seed employed.

**23. Size of seed.** Scores of experiments have been made to determine the size of seed or grain to sow for the best agricultural results. Most of these show a distinct advantage from sowing large or heavy seed.

Zavitz secured the following results:

After thirteen years of seed selecting, the large seed being taken each year from the plot sown with large grains, the small grains continuously from the plots sown with small seed, the crop from the large seed yielded 65.5 bushels per acre as compared with 44.7 bushels from the small seed.

Yet in some experiments where equal weights of heavy and medium-weight seed oats were compared, the latter afforded an equal or even larger yield of grain. This result has doubtless been due to the *greater number* of such seeds, and therefore of plants per acre, and suggests that when especially large seed are sown we should be careful to use an

ample weight of such seed oats, so as to avoid a thin stand of plants.

**24. Separation of grains by fanning.** It should be borne in mind that there is a tendency for any one oat plant to bear as many heavy as light seeds. This is because each spikelet usually matures one large and one small grain. Hence separation by fanning machines tends to place both among the large seeds and among the small seeds grains from the same parent plants. This indicates that for most rapid improvement of the oat, reliance can not be placed chiefly on selection by the use of the fanning machine, but rather on the selection of individual plants.

However, seed oats should be fanned for the following reasons: (1) to eliminate many grass and weed seeds; (2) to remove those oat grains that are too light to germinate or to make vigorous plants; and (3) to decrease the danger of clogging the grain drill with broken straw and trash and beards, especially in the case of the Red rustproof varieties.

**25. Change of seed.** Varieties of oats do not "run out," or degenerate, from being grown continuously in any part of the Cotton Belt in which oats thrive. There is probably a slight advantage in sowing oats grown in the locality where they are to be planted or at least grown under the same climatic conditions.

**26. Cultivation, or intertillage.** It is unusual to till oats after germination occurs. It is probable that in the South, especially on soils inclined to bake, it will be generally advantageous to harrow drilled oats. Harrowing is seldom injurious to the stand of oats sown with the grain drill and not at all hurtful to the oats sown in open furrows.

**27. Pasturing.** During periods when the soil is so dry as to be uninjured in its mechanical condition by the tramp-

ing of live stock, there may be no harm in pasturing oats intended for grain. Late pasturing delays maturity.

Cautions to be observed in pasturing any small grains are: (1) Keep the stock off the land while wet; (2) discontinue pasturage early enough to afford abundant time for the plants to tiller and head; (3) avoid pasturing too closely while there is danger of severe freezes.

For oats sown rather early in the fall, pasturing may be a distinct advantage in preventing the formation of stems while there is still danger of freezing weather, which would be especially injurious to oats in the "booting" stage, that is, after the stems have begun to lengthen rapidly.

## HARVESTING

**28. Time and method of harvesting.** Oat grains mature from the top of the panicle downward. Most of the grains should change color and be in the late dough stage or riper, before being harvested for grain. The harvesting of oats is best done with the self-binder (Fig. 8). When additional day labor can not be hired to shock a large area of oats in a brief time, the harvest season can be spread out over a longer period by sowing a part of the area in Red rustproof oats and a part in some variety ripening either earlier or later.

**29. Yields.** For oats sown in the fall in the Cotton Belt a yield of less than 20 bushels may be regarded as poor; of 20 to 30 bushels as fair; and one exceeding 40 bushels per acre as a good yield.

A medium yield of oat hay is about one ton per acre, which may be increased greatly by the liberal use of nitrate of soda or by sowing seed of hairy vetch or crimson clover with the seed oats in September or October.



*Courtesy U. S. Dept. of Agriculture*

**Fig. 8. — Harvesting Appler oats in South Carolina**

For oats sown after Christmas in the Gulf states, the yields may be taken as not quite two thirds of the figures for fall-sown oats on the same land.

In several instances yields of more than 100 bushels per acre have been reported in the Southern States.

### LABORATORY EXERCISES

#### Young plants in the field.

(1) From a number of plants of wheat, oats, rye, and barley, pulled and mixed together, separate all the oat plants by the absence of clasps (auricles) on the leaves. Repeat until young oat plants are readily recognized.

(2) From an examination of specimens used in (1) or growing in the field, write out other means of distinguishing leaves of oats from those of each of the other small grains.

(3) Compare several varieties of oats, if available, as to differences in appearance of the young plants.

(4) Dig four young plants sprung from seed buried deeply and four others from seed lightly covered; record for each plant of each class the length of that section of root between the parent grain and the crown, or place where most stems originate.

#### Examination of bloom.

(5) Pinch off the smaller flower in a spikelet and treat the larger as follows: With pin or small forceps open the transparent inner hull (palet) before the pollen has been shed, and make a drawing, showing the number and position of the anthers and the stigmas.

#### Crossing oat flowers.

(6) If practicable to execute Exercise (5) at 8 to 10 A.M., practice opening several flowers in such a way as to give least injury to the palet; when successful, remove with a pin the three unopened anthers; carefully replace the palet; cover with a very small paper bag; about 5 P.M. of the same day reopen the same flower and insert on the stigmas an anther that shows loose grains of pollen; replace the palet and a week later note whether a crossed grain has formed. Repeat this exercise several times.

#### Oat panicles and stems.

(7) Compare the form of the panicle of Red rustproof oats with that of Burt or Turf oats.

(8) Record the number of *whorls* (sets of branches) and the number of spikelets in each of five heads of oats.

(9) Record the total number of stems of ten plants with abundant room and of ten plants in a part of the field where the plants are thick.

### Samples of threshed seed.

(10) Make a germination test of 100 small seeds from upper grains of spikelets and of 100 large grains, each of the latter being the lower grain of its spikelet; notice results in seven or fourteen days as to the percentage of germinated seed and the character of sprouts or young plants. (In a good sample, 97 per cent should germinate.)

(11) Note all differences between seeds of Red rustproof, Burt, and Turf types of oats.

(12) Make drawings of a spikelet of Red rustproof oats freed of chaff, showing the number and position of the beards. Do likewise for some other variety.

(13) Determine the weight of a measured bushel of several samples of oats by weighing a gallon or peck.

### Scoring.

(14) Score as many samples of threshed oats as practicable by the following score card or by an approved substitute:

	POINTS
1. Trueness to type. . . . .	15
2. Uniformity of kernel in size and shape . . . . .	10
3. Purity of color . . . . .	15
4. Cleanliness, or freedom from weed seeds, trash, etc. . . . .	10
5. Seed condition, or germinating power. . . . .	15
6. Proportion of hull . . . . .	10
7. Weight per bushel . . . . .	25
Total. . . . .	100

### ADVANCED TOPICS

A. A detailed laboratory study of the structure of the spikelet of oats.

B. A laboratory study of minute differences between the structure of the spikelets, or the grains, of all available varieties of local importance.

C. A library study of yields of varieties at Southern Experiment Stations.

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## CHAPTER II

### WHEAT (*Triticum æstivum*)

Wheat belongs to the grass family and is thus closely related to all the other cereal grains and to the forage grasses. All kinds of wheat are annual.

Wheat is used chiefly for the manufacture of flour. From the wheat grain are also made breakfast foods, macaroni, and other articles for human nourishment. Wheat is a favorite food for poultry; and when low in price, it is sometimes fed to other live stock.

The wheat plant affords valuable winter pasturage; and when cut before ripening, beardless varieties make hay of good quality.

**30. Roots.** All of the roots of a wheat plant are slender and fibrous. From the sprouting grain spring three or more short roots. These form the temporary root system that is useful chiefly during the first few weeks of the life of the little plant. Later the permanent roots put out from a joint (node) on the underground part of the main stem. The permanent roots usually originate about one inch below the surface, even though the seed may have been planted at considerable depth. So the depth at which the plants root and feed is largely independent of the depth of planting.

**31. Stems and leaves.** The stems (culms) of wheat are hollow, with closed, or solid, joints. The usual height is three to five feet. When the straw grows to great length, there is danger that the plant may lodge (fall), thus inter-

fering with the perfect development of the grain and making harvesting difficult and incomplete. As a rule, wheat grows taller than barley and not so tall as rye. The weight of straw is usually nearly twice that of the grain, but it may vary widely from this.

A single wheat grain may give rise directly to a single culm and indirectly to a score or more of stems, as explained below. The buds at the lower nodes of each culm may themselves develop into additional culms, and from the lower nodes of these still other stems may spring. Each new stem develops roots of its own. This formation of culms from lower buds at the underground nodes of each stem explains how and why wheat and other small grains branch, or tiller. The greater the space between plants and the more abundant the rainfall and supply of plant food, the larger may be the number of culms from a single crown.

The leaves of wheat vary in width and even in the shade of green; as a rule, they are narrower than the young leaves of barley and oats.

Young plants of the four small grains may be distinguished easily by the following leaf characters, as well as by others:

Oats have no auricles (Fig. 1).

Rye has very small auricles (Fig. 18).



Fig. 9. — Part of a wheat plant

Note the clasps bordered with hairs at the junction of leaf blade and sheath.

Barley leaves are provided with large auricles (Fig. 21).

Wheat has auricles intermediate in size between those of rye and barley, and on the outer margin of each auricle of common bread wheats are a few hairs (Fig. 9).

**32. Pollination.** Although wanting in showy colors, the part from which each wheat grain develops is a true flower. When one carefully opens the husklike inclosing parts in a newly formed head of wheat, within each flower are found three anthers, which soon afford the yellow powder (pollen). There is also a pair of small glistening *plumes* (Fig. 10), corresponding to the silks in corn. These are the stigmas, or divisions of the pistil, and in these delicate plumes the pollen must lodge and grow before a seed can form.

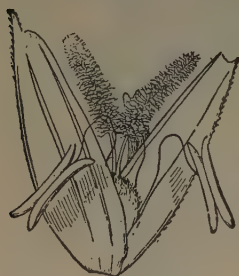


Fig. 10. — Floret of wheat

Note the two stigmas and two of the three anthers.

The plumelike stigmas are snugly inclosed by the chaff, thus preventing the access of any pollen except that which develops within the same flower.

Hence wheat is a self-pollinated plant. Therefore, two varieties of wheat sown side by side do not cross or mix, unless the seed is mechanically mixed by careless handling.

Two varieties of wheat can be crossed, or *hybridized*, by removing the pollen cases (anthers) before they burst, and by applying a little later to the stigmas of this plant pollen from the anthers of another wheat plant.

**33. Spike and spikelet.** *Spike* is the name given to the entire head of wheat, while *spikelet* refers to a group of flowers or grains lying between two chafflike parts, called *glumes*. The head (spike) is borne at the top of each completely developed stem, or straw. In wheat there

is only one spikelet, or flower cluster, at each node. The spikelets are arranged flatwise and alternately on the zig-zag stem, or *rachis*.

The shape of the spike differs in certain species and varieties of wheat and may be (1) tapering, (2) nearly uniform in size, or (3) club-shaped, that is, decidedly larger at the extreme upper end (Fig. 11).

Comprising each spikelet are usually three or more flowers (Fig. 10). From them, when all conditions are favorable, may develop three grains. Sometimes only two flowers develop into grains.

In some varieties a beard, or *awn*, projects from the tips of each lemma (the covering that incloses the rounded part, or back, of each grain). It has not been proved that bearded varieties of wheat are any hardier or any more productive in the South than beardless kinds. The latter usually prove just as productive of grain and decidedly preferable for hay.



Fig. 11. — Four subspecies of wheat, not generally grown

Left to right, branched, club, Polish, and durum, or macaroni, wheat.

**34. Grain.** When wheat is threshed, the grain is freed from the chaff that has enfolded it. The same is true of rye. On the other hand, the hull of oats continues to enfold the grain after threshing, and in barley the hull adheres fast to the grain.

A single grain of wheat is usually about a quarter of an inch long. A deep furrow, or *crease*, extends nearly the length of the grain on the side opposite the germ, or *embryo*. The greater depth of this furrow and the shorter plumper grain readily distinguish a wheat kernel from a grain of rye.

In color wheat grains vary from a light, almost creamy, yellow (called *white*) through an amber tint to dark red. Red and amber-colored wheats are more commonly grown in the South than those of the lighter shades.

The kernel of wheat is divided into three principal parts: (1) the germ (or embryo); (2) the starchy part, or *endosperm*; and (3) the several outer layers constituting the bran. The germ, which may be located by a tiny scar, constitutes only a very small proportion of the grain, occupying only about one thirteenth as much space as the endosperm. The starchy portion (endosperm) is the part from which flour is made. This is a reserve supply of food material stored by the maturing plant for the nourishment of the seedling before the roots can furnish a full supply.

### COMPOSITION

**35. Composition.** In round numbers the entire wheat grain has the following average composition:

	PER CENT
Water . . . . .	10.5
Gluten and other nitrogenous constituents (protein) . . . . .	12.0
Fats, etc. . . . .	a little more than 2.0
Crude fiber . . . . .	a little less than 2.0
Ash . . . . .	a little less than 2.0
Starch and other nitrogen-free extract . . . . .	more than 71.5
Total . . . . .	100.0

The higher the percentage of protein in normally matured wheat grains, the higher, as a rule, are the quality and bread-making value of the wheat. The protein is often as much as 2 per cent either above or below the average just given, and still greater extremes in composition sometimes occur. Any climatic or other condition that prevents the complete maturity of the wheat into plump grains tends to reduce the proportion of starch, which is the material last to be added to the grain; this reduction in the percentage of starch naturally raises the percentage of nitrogen. It has been found at the Tennessee Experiment Station (*Bulletin*, Vol. XVI, No. 4) that wheat grown in the South contains a high percentage of protein. Hard grains, which present a horny appearance, are usually richer in protein than those which have a less flinty appearance.

Gluten, the principal nitrogenous constituent in wheat, is not only prized for its high nutritive value, but also because to its presence is due the "rising power" possessed by wheat flour as compared with flour or meal from Indian corn. Gluten is the sticky residue left in the mouth when one chews unground wheat grains. The favorable action of this sticky gluten in making flour bread rise, or become "light," is due to the fact that the gluten entangles and holds in the dough the bubbles of carbonic acid gas formed by fermentation when yeast is added to dough.

#### SPECIES AND VARIETIES

**36. Species and subspecies.** The genus *Triticum*, to which all forms of wheat belong, includes eight species or subspecies. Only one of these is generally cultivated in the South; namely, the winter-growing form of common wheat (*Triticum aestivum*).

*Macaroni wheat* (Fig. 11) is adapted to a semiarid climate. At least one of its varieties, under the name of Nicaragua wheat, has been grown successfully in the drier portions of Texas. Macaroni wheat in that climate makes a large yield of grain, which is suitable either for the manufacture of macaroni or vermicelli or for stock food. Macaroni wheat is bearded. In its early growth it is more erect, and the plant is less inclined to stool than common wheat. It is also called durum, or hard, wheat.

Other forms of wheat, not grown in the South, are the following:

*Club wheat* (Fig. 11) is a favorite variety in parts of California, Oregon, and Washington. Its special value lies in its resistance to shattering.

*Branched wheat* (Fig. 11) is so named because the head is branched. In this class belongs the inferior variety, Alaska.

*Polish wheat* (Fig. 11) is characterized by very long heads and extremely large kernels and glumes.

*Spelt* and *emmer* are forms in which the chaffy coverings cling to the grain after threshing; hence they are grown for stock feed.

**37. Varieties.** Although hundreds of varieties of wheat are known, those extensively grown in the Cotton Belt are probably less than a score in number. Among the most popular and productive varieties are the following:

*Blue Stem, or Purple Straw* (Fig. 12), is so named because of the purplish tint on the upper part of the ripened straw. It is beardless and hence suitable for hay as well as for grain. When the seeds are continuously grown in the South, it is one of the earliest varieties. The grain is amber-colored or reddish and of medium size.

*Fultz* (Fig. 12) is widely grown in the South. It is prac-

tically beardless though very short beards are found in the upper part of the head on a few of the glumes, or chaffy parts. It may be used for hay as well as for grain.

*Red May* is an early beardless variety.

*Fulcaster* (Fig. 12) is a bearded variety widely grown in the South and generally found to be comparatively hardy and productive.

**38. Most productive varieties of wheat.** There is no one variety of wheat that is best for all seasons and for all localities in the South. This explains why variety tests present such different results in successive years.

In experiments made at the Test Farms in North Carolina, during several years, Golden Chaff, Bearded Fulcaster, and Improved Amber were among the most productive varieties.

At the Alabama Experiment Station a local strain of Purple Straw has been the earliest and one of the most pro-



Fig. 12. — Four varieties of wheat popular in the South

Left to right, Fulcaster, Fultz, Purple Straw, and Currell.

ductive varieties tested. Fulcaster has also made good yields of grain.

At the Oklahoma Station Sibley's New Golden was one of the best. This is a bearded variety with soft grains. At the same station good yields were also made by Blue Stem and Fulcaster, and by some of the hard wheats, including among others, Turkey Red. (Oklahoma Experiment Station *Annual Report*, 1908-1909.)

**39. Means of distinguishing varieties.** Varieties are distinguished by the presence or absence of beards; by the color of grain; by the color of chaff; by the presence or absence of hairs (*velvet*) on the chaff; by the height of straw; by the time of maturity; and by other characters. Hence, it is evident that a variety can not be identified merely by an inspection of the grain itself.

**40. Improvement of varieties.** The qualities chiefly desired in varieties of wheat for the South are the following: (1) high yield; (2) earliness and rust resistance; (3) a rather high percentage of protein; and (4) stout straw to keep the maturing plants from falling down (Fig. 13).

Wheat can be improved readily by selecting for seed the best individual plants; for example, those affording a larger yield than other plants having an equal amount of space and fertilizer or those most resistant to rust or the earliest productive plants. Improvement will be more rapid if farmers specially interested in breeding up their wheat would set apart small areas for use as breeding nurseries where the seed from each selected plant could be sown in a separate row. The seed from the best of these rows should be planted the next year.

**41. Soils.** Wheat thrives better on a clay or loam soil than on one that is sandy. Most suitable of all is a lime soil if it also contains considerable clay. Wheat does not

thrive on acid soils; these are made more suitable by applying one ton or more of ground limestone per acre.

Bottom lands of suitable character in favorable years afford large yields of wheat, but this plant is more subject to rust and lodging on bottom lands than elsewhere.

In the northern part of most of the Gulf states are many soils suitable for wheat, after they have been somewhat



*From Ladd's Dairy Farming*

Fig. 13. — A field of lodged grain

improved by the addition of vegetable matter. Among such soils may be especially noted the limestone valleys and also the reddish-clay or clay-loam soils of the Piedmont region or foothills. Likewise, the waxy lime lands of central Alabama, of northeastern Mississippi, and of

Texas offer suitable conditions for the growth of wheat when sufficient vegetable matter is incorporated.

Wheat needs a rich or fairly rich soil. More economical than the use of most forms of commercial fertilizer is the improvement of the soil for wheat by a preceding crop of cowpeas or of other legumes. This is the cheapest means of adding nitrogen, the most expensive plant food purchased in commercial fertilizers. The preceding crop of legumes should be fertilized with acid phosphate so as to enable the legumes to make a more luxuriant growth and thus to add more nitrogen to the soil.

**42. Place in the rotation.** In the Cotton Belt the crop preceding wheat is usually cowpeas, either grown alone or as a catch crop between rows of corn. It is not unusual for a growth of cowpeas to add 4 to 10 bushels per acre to the yield of the following wheat crop.

The following four-year rotation is often desirable:

First year: cotton, with crimson clover seeded in September between the rows.

Second year: cotton.

Third year: corn, with cowpeas between the rows.

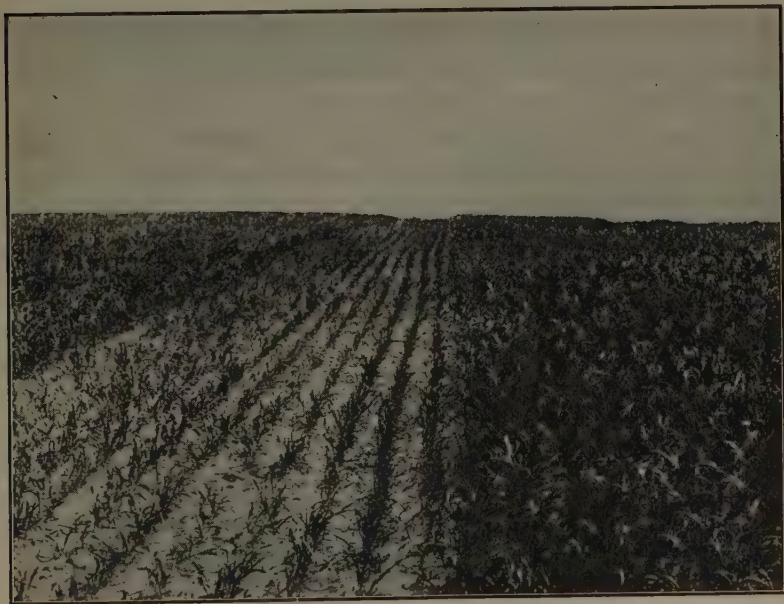
Fourth year: wheat, followed by cowpeas.

**43. Fertilization.** A crop of 25 bushels of wheat, with its accompaniment of about 2500 pounds of straw, removes from the land approximately the following amounts of plant food:

TABLE III. PLANT FOOD REMOVED FROM THE SOIL  
BY A WHEAT CROP

	NITROGEN (Pounds)	PHOSPHORIC ACID (Pounds)	POTASH (Pounds)
25 bu. grain . . . . .	25.9	14.4	5.3
2500 lb. straw . . . . .	10.8	3.3	18.5
Total in grain and straw . . . . .	36.7	17.7	23.8

These figures indicate that the grain depletes the land of considerable quantities of nitrogen and phosphoric acid, while the straw removes a large amount of potash and also considerable nitrogen. The straw, after being used as food or bedding, should be restored to the farm in the form of



*Courtesy Kansas Agricultural College*

**Fig. 14. — Effect of fertilizer on wheat**

The center strip was unfertilized. Note the fertilized areas on each side.

manure. This, however, will usually not be applied to the field from which the straw was taken.

Phosphoric acid is very generally deficient in Southern soils. Phosphate is the fertilizer usually applied to wheat (Fig. 14). Two hundred to four hundred pounds per acre may well be employed. The time to apply acid phosphate to wheat is at the sowing of the grain. This may be done

through the fertilizer attachment of the grain drill and while the seed is being sown. The germination is not injured by the contact of the phosphate with the seed.

Since wheat makes most of its growth during the cooler part of the year, while decay and nitrification are least active, this plant responds profitably to applications of nitrogenous fertilizers. For the reason just indicated the most readily soluble form of nitrogen, nitrate of soda, is usually the most effective for conveying at least a part of the supply of nitrogen to the wheat plant. On account of its ready solubility, nitrate of soda is not usually applied until winter is past and the plants have a well-developed root system ready to appropriate the soluble nitrates. It is well to apply nitrate of soda at least two months before the date of anticipated harvest.

This usually means that in the Gulf states nitrate of soda should be used by or before the twentieth of March and in higher latitudes at proportionately later dates; eighty pounds per acre is the amount most generally advisable, though profitable use can often be made of amounts smaller or larger by 50 per cent. Nitrate of soda should be sown very uniformly after all lumps have been pulverized. No covering is required; but when harrowing can be done without serious injury to the stand of plants, it will often be helpful both as a means of hastening the absorption of the nitrate of soda and also for its effects as a cultivation.

### CULTURAL METHODS

**44. Preparation of land.** Wheat requires a carefully prepared seed bed, moderately compact in the lower layers, and loose and fine near the surface. In order to permit the soil to settle or become moderately compacted by rain,

plowing for wheat should be done, if practicable, at least several weeks before the anticipated date of sowing the seed. In Oklahoma it has been found advantageous to plow for wheat as early as midsummer. Plowing three to six weeks before seeding is often advisable; but when wheat follows catch crops of cowpeas, it is often necessary to sow it soon after plowing under the cowpea stubble and to rely on harrowing and rolling to compact the soil. Immediately after plowing and before the upturned soil has dried into clods, the field should be harrowed.

**45. When to sow wheat.** The kind of wheat grown in the South should be sown in the fall. In the Gulf states some wheat is sown as late as the first part of December. This is too late for the maximum yield, even in the central or southern parts of the Gulf states.

In the absence of the Hessian fly, early sowing of wheat usually produces the maximum yield. However, where this insect occurs, sowing is postponed, if practicable, as late as necessary to insure that the young wheat plants do not come up until after killing frost discourages the laying of eggs by the Hessian fly (Figs. 15, 26).

A. D. Hopkins (*United States Weather Review*, Supplement 9, May 1, 1918) gives the following as safe dates for sowing wheat to escape injury by the Hessian fly:

Georgia and South Carolina, October 25 to November 25.

Central Tennessee, October 15 to 25.

Central Kentucky, October 5 to 15.

Virginia (near sea level), and northern Oklahoma, second week in October.

Hopkins also finds that the safe date for sowing varies:

4 days for 1° of latitude (earlier northward)

4 days for 5° of longitude (earlier eastward)

4 days for each 400 feet of elevation (earlier upward)



The increased yield from drilling at the Kentucky Experiment Station averaged 4 bushels per acre.

The slight ridges left by the grain drill are advantageous in the colder parts of Virginia and Kentucky, and still more so further north, since they hold the snow and thus keep the plants warmer than they would be if exposed to very severe cold without the covering of snow.

**47. Seeding machines.** Of the several types of grain drills, the disk drills (Fig. 5) are preferable, especially where there is much litter, stone, or other kinds of obstruction. For land that is clean and in excellent condition, the hoe drill and the shoe drill are also satisfactory. Most drills are provided with fertilizer attachments, and attachments for sowing grass or clover seed can also be purchased.

Broadcast sowing is usually done by hand. Yet there are cheap and efficient broadcast seeders that may be hung from the sower's shoulders; there are also broadcast seeders that may be attached to the rear end of a wagon and driven by the revolution of the wagon wheels.

**48. Quantity of seed.** In the wheat-growing states great numbers of experiments have been made on this point. The results have been variable from year to year, with different soils and climates, and with several varieties. In general the highest yields have seldom been made with less than 5 pecks of seed.

**49. Large *versus* medium and small seed.** In numerous experiments in Europe and America comparisons have been made between the large and the small seed of wheat, as separated by sieves, and ordinary seed. The results have been variable. Apparently it pays to select the largest grains by means of sieves or other devices connected with fanning machines, provided a larger volume of the larger

seed be sown, so as to afford the same number of plants as a smaller weight of lighter seed. See Fig. 16.

**50. Change of seed.** As a general rule, there is no advantage, and often a decided loss in yield, in bringing seed wheat from a different latitude, instead of sowing grain grown in the same climate. Southern seed wheat for Southern fields should be the rule, except where the home-grown



Fig. 16. — Samples of poor and good wheat grains

On left, not fertilized; yield 2.7 bushels; grains shriveled; on right, fertilized; yield 19.4 bushels; plump grains.

crop has been a failure, resulting in small shrunken grains. There is no inherent advantage in change of seed. Acclimatized seed is more productive and, in the case of wheat, earlier.

### HARVESTING

**51. Time to harvest wheat.** The proper time for harvesting wheat is indicated by both the color of the straw and the degree of hardness of the grain. Wheat should be cut when the individual grains are soft enough to be indented



*Photo from Ewing Galloway*

**Fig. 17. — Threshing wheat in Arkansas**

by the finger nail, but too hard to be easily crushed between the thumb and finger. At this stage of maturity, the straw of most plants will have turned yellowish. However, when rust is prevalent and increasing, earlier harvesting of the grain crop is advisable.

Wheat is best cut and tied by the self-binder. It should be shocked and capped promptly. Some farmers thresh from the shock a few weeks after harvest, but it is safer to place the sheaf wheat in stack or barn until ready to thresh. Threshing is usually done by crews that travel from farm to farm (Fig. 17).

**52. When to cut wheat for hay.** Wheat for hay is probably best cut when in the "late milk stage," but, if rust is absent, mowing may be deferred until the grain is in the "early dough stage." If rust promises to be severe, wheat may be mowed while still in bloom.

**53. Yields and prices.** The legal weight of a bushel of wheat is 60 pounds. A measured bushel may weigh a few pounds above or below this. The heavier a bushel of wheat, the better is the quality. The average yield of wheat in the entire United States for the ten-year period ending in 1922 was 14.4 bushels per acre. The average of the cotton states is considerably below this figure; but individual farmers sometimes produce an average of more than 20 bushels per acre.

### LABORATORY EXERCISES

#### Young plants.

(1) Repeated tests should be made of the student's ability to distinguish the young plants of wheat, oats, barley, and rye by the auricles (Figs. 1, 9, 18, 21). If no young plants are available, leaves of mature plants may be used for the same purpose, after dampening them.

(2) Select five young wheat plants, each having abundant space around it, and record (a) total number of stems and (b) average number of stems per plant.

(3) Repeat Exercise (2) with five plants closely crowded by other plants. Compare figures for (2) with those for (3).

(4) Plant 25 kernels of wheat at each of the following depths:  $\frac{1}{2}$  inch, 1 inch, 2, 3, 4, 5, and 6 inches. Keep the soil moderately moist; at intervals of a week record the number of plants that have come up from each depth of planting.

(5) After the plants from the deeper depths have been up for two or more weeks and again at a much later date, carefully dig several plants from plantings made at each depth, and record the distances below the surface at which the principal roots are growing or depths at which the crown is forming.

### Mature plants.

(6) If drilled and broadcast wheat are both available, ascertain (by digging the plants) the average number of plants and of stems per square foot of ground surface with each of these two methods of sowing.

(7) From wheat heading in the field or from dried specimens record the following data for as many varieties as are commonly grown in the locality:

- (a) Average height of plant.
- (b) Average number of stems bearing heads.
- (c) Bearded, beardless, or partly bearded.
- (d) Estimated percentage of upper leaf surface covered by rust.
- (e) Has rust attacked the stems slightly, considerably, or not at all?
- (8) From dried mature plants in the laboratory, after being moistened, or from nearly mature specimens from the field, describe in writing each of the varieties indicated by the instructor as to the following points:
  - (a) Bearded, beardless, or partly bearded.
  - (b) Average length of head.
  - (c) Average number of spikelets per head.
  - (d) Difference, if any, in usual number of grains per spikelet in tip, middle, and base of head.
  - (e) Difference, if any, in size of grains in tip, middle, and base of head.
  - (f) Difference in size of middle grain in a spikelet compared with the two outer grains.

### Character of grain.

(9) For varieties commonly grown in the locality record a description as to each of the following points:

- (a) Prevailing color — whitish, amber, or reddish.

- (b) Hard, medium, or soft in crushing.  
 (c) Plump, shriveled, or medium-plump.  
 (d) Size of grain — large, medium, or small.  
 (e) Crease — deep, medium, or shallow.

(10) Standards for wheat grown in the South have not been agreed on. Until this is done, the following standard for Fultz wheat used in Kansas may prove a useful basis for the formulation of Southern standards.

Type: red, soft, winter.

Length of berry:  $\frac{7}{8}$  to  $\frac{8}{8}$  inch.

Thickness of berry:  $\frac{8}{8}$  to  $\frac{4}{8}$  inch.

Shape and plumpness: very plump, rounded sides; shallow groove.

Moisture content: per cent, 10.

Weight per bushel: pounds, 60.

Percentage of soft grains, 90.

Practice scoring wheat grain by the following score card or such modification of it as the instructor may direct:

	PERFECT SCORE	DEDUCT FOR EACH PER CENT UNDE- SIRABLE	1	2	3	4	5
1. Trueness to variety . . . . .	10	$\frac{1}{10}$					
2. Uniformity in size and shape of kernel . . . . .	10	$\frac{1}{10}$					
3. Color of grain . . . . .	10	$\frac{1}{10}$					
4. Freedom from mixture with other grain . . . . .	15	$\frac{1}{2}$					
5. Size of kernel . . . . .	10	$\frac{1}{2}$					
6. Per cent and nature of weed seed, dirt, etc. . . . .	15	1					
7. Per cent of damaged, smutty, or musty kernels . . . . .	5	1					
8. Weight of grain per bushel . . . . .	10	1					
9. Germination . . . . .	15	1					
Total . . . . .	100						

### ADVANCED TOPICS

- A. A detailed laboratory study of the wheat spikelet and wheat grain.  
 B. Characteristics and yield records at Southern Experiment Stations of the leading Southern varieties of wheat.  
 C. A library study of the effect of climate on the quality of wheat.

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## CHAPTER III

### RYE AND BARLEY—DISEASES OF THE SMALL GRAINS

In the South rye and barley are grown only on a small scale and chiefly for pasturage in winter and spring. Barley is the principal small grain in California and other parts of the extreme Southwest.

#### RYE (*Secale cereale*)

**54. Use and description.** Most of the rye grain threshed in the Southern States is used as seed. The rye plant makes hay of very poor quality. The grain of rye, like that of wheat, has no adhering hull after it has passed through the threshing machine. It may be distinguished from a wheat grain by the longer slenderer shape, the more pointed base, and the more shallow crease.

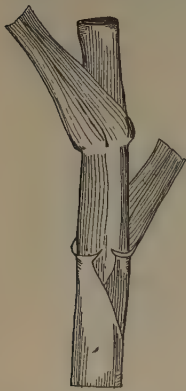


Fig. 18. — Part of a rye plant

Note the small clasps at junction of leaf blade and sheath.

The head of rye (Fig. 19) is longer than that of wheat or barley, and the beards are not so widely spread as in bearded wheat or barley.

The young plant of rye may be distinguished from young wheat and barley by the very small auricles (Fig. 18) and by the reddish color of the first leaf sheath. The foliage is commonly of a grayer green than that of the other smaller grains.

**55. Varieties.** There is but a limited number of varieties of rye, even in European countries. Practically only two varieties are successfully and generally grown in the warmer

portion of the South; namely, Southern and Abruzzi (Fig. 19).

The rye flower, unlike that of wheat, oats, and barley, is cross-pollinated; so it would not be desirable to sow two different varieties near together.

**56. Climate.** The rye plant is adapted to a wide range of climate. It is hardier to cold weather than any of the other small grains and is practically never injured in the South by winter killing. Rye can be sown successfully in a latitude too far south for general success with wheat. However, in growing rye in the South, it is very important to use seed grown as far south as practicable. Seed from the central and lower parts of the Gulf states is better than that from the extreme northern sections of the same states and far better than that from still higher latitudes. Northern rye spreads out so closely to the ground that it does not afford the best early winter pasturage, and seeds from higher latitudes produce smaller plants that are later and more subject to rust than is Southern rye.

**57. Soils and fertilizers.** Rye can be grown on almost any soil, provided it is fairly well drained. It has been found to endure a greater amount of acidity in the soil than oats, wheat, or barley plants. (Rhode Island Experiment Station *Report*, 1907.)

While rye will grow on poor soils, it is possible to make large yields of forage only on rich or highly fertilized land. With rye intended for soiling, a liberal use of stable manure constitutes the best fertilization. If commercial fertilizers



*Courtesy Cal. Exp. Sta.*

**Fig. 19.** —  
Abruzzi rye

alone must be used, it is usually advisable to apply acid phosphate; in addition an early application of nitrate of soda may be made. On very sandy soils there may be need for a small amount of potash.



*Courtesy U. S. Dept. of Agriculture*

**Fig. 20.** — Rye makes a fine pasture

**58. Preparation and sowing.** Rye may be sown either (1) broadcast or (2) in drills 6 to 8 inches apart by the use of a grain drill or (3) by hand or planter in drills 18 to 24 inches apart. For soiling purposes it is preferable to sow in drills, but for grazing broadcast sowing is the more

common. Rye may be sown through a longer period than any of the other small grains, that is, from about the first of September to the middle of December. Late sowing affords a reduced yield. When sown broadcast, the amount of seed needed for a winter cover crop in cotton fields is 2 to 4 pecks per acre; for grain production, 4 to 5 pecks; and for pasturage, 6 to 8 pecks. Rye may be sown with crimson clover, vetch, or other winter-growing legume. Rye weighs 56 pounds to the bushel.

**59. Utilization.** On rich land rye sown early in the fall may be cut three or even four times as a soiling crop, the first cutting being made in December or January. In order to secure several cuttings, the plant must be cut just before the heads appear. Southern rye is somewhat earlier in maturing than most varieties of wheat or oats.

Rye for pasturage must be kept rather closely grazed in the spring, or else some of the plants will develop tall stems, and in this condition these plants will not be eaten readily by live stock.

### BARLEY (*Hordeum vulgare*)

**60. Use, culture, and description.** The chief use of barley in the South is for pasturage and as a soiling plant. It is sown in the same way as rye. Green barley is considered to be more palatable than pastures of any of the other small grains. Cultural operations are practically the same for barley as for wheat. Some varieties of barley have shorter straw and mature in less time than any of the other small grains. The heads are usually armed with strong, long, spreading beards, that



Fig. 21. — Part of a barley plant

Note the large clasps where leaf blade and leaf sheath join.

grow from the tips of the glumes (Fig. 23). In spite of this objection, barley is grown in California as a hay plant, but its use necessitates the occasional removal of the beards from the gums of horses consuming it. The clasps at the junction of leaf sheath and leaf blade are larger on the barley plant than on any other of the small grains (Fig. 21).

The hull of the barley grain grows tight to the kernel, and the grain, instead of being roundish, as in oats, has a

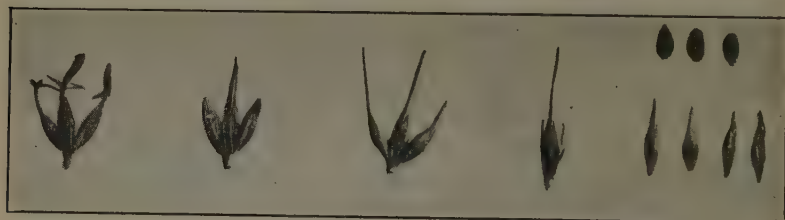


Fig. 22. — Barley spikelets and grains

Left to right, hooded, Arlington awnless, six-rowed, two-rowed and grains of common barley (below) and of hull-less barley (above).

distinctly ribbed or angular appearance. The hull constitutes less than one sixth of the weight of the entire grain. Barley weighs 48 pounds to the bushel.

**61. Composition.** The following figures show the relative composition of the seeds or grains of barley, rye, wheat, oats, and Indian corn:

TABLE IV. COMPOSITION OF SEEDS OF BARLEY, RYE, WHEAT, OATS, AND CORN

	PROTEIN (Per cent)	FAT (Per cent)	CRUDE FIBER (Per cent)	CARBO- HYDRATES (Per cent)
Barley, grain . . . . .	12.4	1.8	2.7	69.8
Rye, grain . . . . .	10.6	1.7	1.7	72.5
Wheat, grain . . . . .	12.0	2.0	2.0	71.5
Oats, grain . . . . .	11.8	5.0	9.5	59.7
Corn, dent . . . . .	10.3	5.0	2.2	70.4

These figures show that barley is a nutritious grain. In cooler countries, where its yield is greater than in the South, it is prized as a food for hogs, since it produces a firm and excellent quality of pork. It is fed to all classes of live stock.

**62. Species and varieties.** Some authorities divide barley into several species, depending on whether the grains are



**Fig. 23. — Four types of barley heads**

Left to right, hooded, Arlington awnless, two-rowed, and six-rowed.

arranged in two, "four," or six rows, thus giving the names, "two-rowed," "four-rowed," and "six-rowed" barley. The variety most generally hardy and productive throughout the South is the Tennessee winter barley. This has long spreading beards and grains arranged in six rows.

*Beardless barley* (represented by the Arlington Awnless) has excited some interest. Its chief advantage is its earli-

ness and the practical absence of beards (Fig. 23). Its disadvantages are small yield of grain, ease of shattering, weak straw, small number of stems produced, and extreme tenderness, or susceptibility to winter killing.

In *hooded barley* (Fig. 23) there are no beards, but a curious, short, three-pointed tip. The variety chiefly grown in the United States makes few stems per plant, has weak straw, is rather tender to cold, and produces low yields of grain.

**63. Soils and fertilizers.** Barley thrives best on a rich clay loam. It prefers a limestone soil, and on acid lands the use of lime is usually advantageous. The fertilizer should be either stable manure or a mixture of commercial fertilizers containing nitrogen, phosphoric acid, and potash.

**64. Sowing.** In the central part of the Cotton Belt barley may be sown at any date between September 1 and December 1. For sowing broadcast to afford pasturage, it is advisable to use  $2\frac{1}{2}$  bushels of seed per acre. For grain production or for sowing in drills as a soiling crop,  $1\frac{1}{2}$  to 2 bushels per acre is sufficient.

#### DISEASES AND OTHER ENEMIES OF THE SMALL GRAINS

Various diseases attack all of the small grains and result in a great reduction in the yields of wheat, oats, barley, and rye. The most widely spread of these diseases are the various rusts and several different smuts. By learning the nature of these diseases and the remedies effective against some of them, the farmer will be able to prevent much of the loss of grain that now occurs.

**65. Causes of plant diseases.** Most plant diseases are caused by minute forms of vegetable life, chiefly fungi, that are often spoken of as disease-producing germs. These

microorganisms gain entrance to the tissues of the crop plant at certain stages of its growth. There these fungi continue to grow, usually as slender branched threads, and consume elaborated food or the tissues of the host plant. Most of these germs known to cause plant diseases have an inactive stage, nearly corresponding to the seed stage of higher plants. These seedlike *spores* are so light as to be blown readily great distances by wind, thus spreading plant diseases.

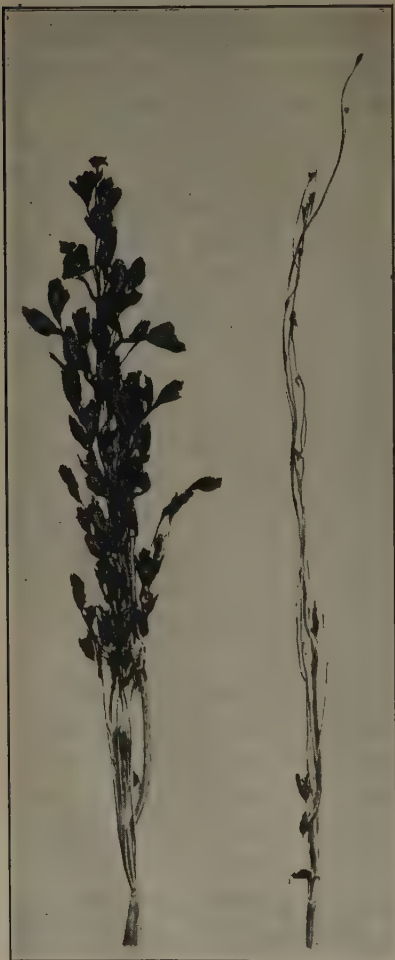
**66. Prevention of diseases among plants.** Some of the most destructive diseases of plants can be prevented by killing the spores. This is generally the case when the disease germs occur only on the outside of the seed. After the spore has germinated and the threads of the fungus are growing in the interior of the plant, treatment is not effective.

Fortunately the spores of most fungi that cause diseases of grains are killed more easily by heat or by certain chemicals than are the seeds of the crop plants on which they are borne. The chemicals most widely used to destroy disease-producing spores on grains are formalin (formaldehyde) and compounds of copper, especially bluestone (copper sulfate).

**67. Loose smut of oats (*Ustilago avenæ*).** In fields of headed oats one often finds some stems on which there is only a mass of black powder instead of seeds (Fig. 24). This consists of millions of spores. They are carried on the planted grain, and during its germination they also germinate and gain entrance to the tiny seedling. The slender fungous threads grow as the grain plants grow and produce black spores when they reach the new grain flowers.

This disease can be prevented easily and completely by thoroughly moistening the seed oats with formaldehyde

(1 ounce to each 2 gallons of water). The wet seeds are covered for a few hours, so that the gas formed may more completely envelop every grain.



Courtesy U. S. Dept. of Agriculture

Fig. 24. — Oat smut

**68. Stinking smut of wheat (*Tilletia tritici*).** In this disease the powdery stinking masses of spores are covered by the inclosing envelopes of the wheat grain. Hence it is also called the *concealed* smut of wheat, or *bunt*. It can be prevented by the use of formaldehyde, just as in oat smut, or by the use of copper compounds. (Two ounces copper carbonate dust with each bushel of wheat).

**69. Loose smut of wheat (*Ustilago tritici*).** The appearance of the blackened heads of wheat is so much like that of oat smut that one naturally suspects the conspicuous smuts of these two grains to be caused by the same microörganism. However, the germs causing the two diseases are different species though both kinds are carried on the planted seed.

Moreover, the germ of

loose smut of wheat is not, like that of oat smut, merely on the surface of the seed. Instead, the former organism is imbedded in the grain of the sound, but infected, kernel that is planted. Therefore, the treatment of the surface of the seed with formalin or with a copper compound will not destroy the embedded disease germs. Only heat is effective (129° F. for ten minutes), applied after the organism has been made more sensitive to heat by previous soaking in cold water for about four hours. This treatment may reduce germination and require thick sowing, and hence it is recommended, not for the entire farm, but only for the wheat sown on a special patch that is to furnish the future supply of seed wheat.

**70. Two smuts of barley.** The covered smut of barley (*Ustilago hordei*) may be prevented by treating the seed with formaldehyde in the same way as for oat smut or for the concealed or stinking smut of wheat. The more conspicuous naked smut of barley (*Ustilago nuda*) (which somewhat resembles the loose smut of wheat) requires, like the latter, a modified hot-water treatment. As barley grains are easily injured, they, after being soaked for about four hours, are heated to only 126° F. and are held at that temperature for thirteen minutes.

**71. The rusts of small grains.** The rusts are not preventable by seed treatment. There are many distinct kinds some of which attack only wheat, others only oats, and still others several of the small grains.

A common form is the orange (-colored) leaf rust (*Puccinia rubigo-vera*), some of the races of which attack wheat, oats, barley, and rye, producing reddish spots on the leaves and stems. A kind that is less commonly present, but even more destructive is the black stem rust (*Puccinia graminis*). The fungi that cause the latter disease include

rices that attack each of the four small grains. The black stem rust of wheat spends one stage of its life on a plant very different from grain. This is a certain kind of barberry shrub, occurring in many of the chief grain-producing states. This particular barberry is being destroyed systematically in such states.

**72. Minimizing the injury from rust.** Varieties ripening early usually escape with least injury. Some progress is being made in breeding varieties less susceptible to the various rusts. Plants are believed to be least injured by rust when so grown as otherwise to be most healthy. The use of excessive amounts of nitrogen unaccompanied by the other plant foods necessary to a healthy growth is believed to make grains more susceptible to rust.



Fig. 25. —  
Ergot of rye

**73. A disease of rye.** Ergot (*Claviceps purpurea*) is a fungous disease of rye which causes the affected grains to enlarge and project conspicuously from the head (Fig. 25), such grains constituting a poisonous food. Preventive measures consist in avoiding the use of seed rye containing such diseased grains and in sowing rye on a field where before there has not been ergot on rye or on any of the related wild grasses.

**74. Insect enemies of the small grains.** The Hessian fly (Fig. 26) is a serious insect enemy of wheat. It does much less damage to rye and barley. From the egg laid on the leaf blades of the young plants, hatch tiny insects, which find their way to a point within the leaf sheath, where in spring the injuries they inflict cause many of the stems to break and fall over. Helpful measures against this insect are rotation of crops and postponement of sowing until a severe



Fig. 26. — Diagram showing the development of the Hessian fly (after Walton, U. S. Bureau of Entomology)

From Colvin and Stevenson's Farm Projects

frost occurs (Fig. 15). The chinch bug is also responsible for great losses in the wheat crop.

In the shock, stack, or bin the wheat grain is attacked by weevils and by the larval or worm stage of the small gray grain moth. The remedies consist in prompt threshing of the grain and in placing near the top of the tight bin of threshed grain one pound of carbon disulfid for each thirty bushels of grain. This liquid promptly vaporizes. The vapors are destructive to insect life. They are also quite inflammable; so no fire, or light, or smoking should be permitted about the granary while grain is being thus fumigated.

### LABORATORY EXERCISES

- (1) Make a drawing of a spikelet of rye.
- (2) Make a drawing of a spikelet of barley.
- (3) Practice the separation of a mixture of grains of barley, rye, wheat, and oats.
- (4) Write out the two most conspicuous differences between a head of rye and one of barley; the one most conspicuous difference between heads of bearded wheat and bearded barley.
- (5) Encircle with a barrel hoop or the sides of a bottomless box a number of oat plants in the field; count the number of smutted and of healthy heads; calculate the percentage of smutted heads and the apparent loss per acre from smut if the yield of the field would have been thirty bushels per acre had there been no smut.
- (6) Carry out directions for prevention of smut by the formalin treatment.
- (7) Save some seed from (6) above and make a germination test, in soil or in a germinating box, of 100 seeds treated with formalin and 100 not treated.

### ADVANCED TOPICS

- A. The detailed structure of the group of spikelets found at each node of two-rowed and of six-rowed barley heads.
- B. A library study of the culture of barley without irrigation in semi-arid regions.
- C. The detailed characteristics of varieties of rye and barley.
- D. Extended study of the principal diseases of wheat, oats, rye, and barley.

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## CHAPTER IV

### CORN, OR MAIZE (*Zea mays*)

Corn, or maize, or Indian corn, belongs to the great family of grasses. It is a large annual, making its growth in the warmer part of the year and is easily killed by frost. Most authorities think that this plant originated in the southern part of Mexico. It has few near relatives among either wild or cultivated plants.

Corn is the largest and most valuable single crop grown in the United States, occupying more than twice the acreage devoted to wheat and three times that devoted to cotton. Its most important use is as a food for live stock, for which the grain and all parts of the vegetative portion of the plant are employed.

Corn also constitutes an important article of human food, especially in the South. From the grain are manufactured starch, sirup, and corn oil. Many other industrial products are obtained from the grain or stem of corn.

#### STRUCTURE OF THE PLANT

**75. Roots.** The root system (Fig. 27) of the corn plant consists of a number of long, slender, branched, fibrous roots. There is no taproot. A whorl of roots develops near the germinating grain, but the main system springs from the crown of the plant, which usually develops about one inch below the surface. Therefore the depth of rooting of corn is largely independent of the depth at which the grain is planted.

As a rule, most of the main feeding roots originate in the stratum comprised between two inches and four inches below the surface of the ground. The roots of corn are frequently as long as the plant is tall. Indeed, the roots may lap across the rows before the plant is one foot high, and so deep cultivation, even at this early stage, may break many roots.

**76. Stem.** The stem of the corn plant is solid, or filled with pith, and tapers to the top. The usual height is five to fifteen feet. A height above ten feet is probably an indication of wasted

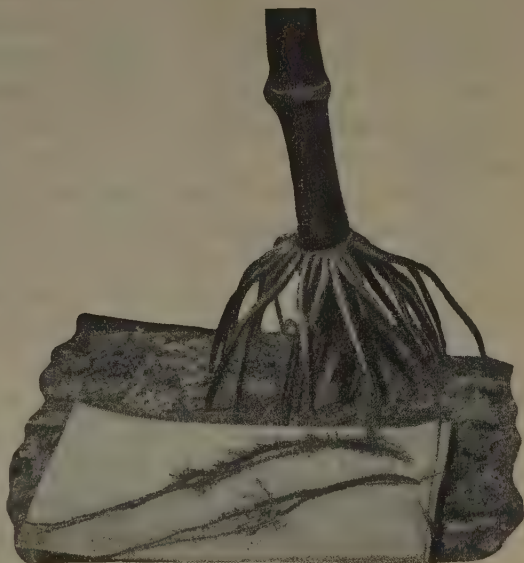


Fig. 27. — Brace roots of the corn plant

energy, the proportion of stem being larger than necessary to the production of the maximum amount of grain.

Since the corn plant must stand much strain from the wind, it is so constructed as to resist or escape or withstand wind pressure. For example, devices for this purpose are found in the tapering stem, the presence of brace roots, the strength of the outer layer, or rind, the solid partitions at the nodes, and the peculiar form of the leaf.

The stem consists of internodes of variable length, sep-

arated by solid partitions at the joints. The internodes on certain parts of the plant are grooved, which seems to be a provision for accommodating the *shank*, or ear branch. When shoots of ears arise, they spring from a bud at the base of this groove. This bud is completely enwrapped by the leaf sheath, which serves to protect it.

Under some conditions, partly dependent on variety, character of season, and distance between plants, *suckers*, or basal branches, spring from the buds on the main stem near the crown.

In experiments in North Carolina the retention of ear-bearing suckers increased the yield.

The tendency of individual corn plants to sucker is hereditary or partly dependent on the variety.

**77. Leaves.** The main uses, or functions, of leaves are: (1) to take up from the air its carbon dioxid for use in building up the tissues of the plant and (2) to throw off the surplus water into the air, thus helping to lift other supplies of soil moisture to the leaves with the contained plant food. For these two purposes the leaf is provided with immense numbers of minute openings, or pores (*stomata*). Each of these is furnished with guard cells by which in dry weather the size of the opening is reduced, thus decreasing the amount of water thrown off by the leaf.

The corn leaf has also another means of economizing in the transpiration of moisture. This is seen in the rolling together of leaves in the middle of a hot dry day. This curling, or rolling, of the leaves is due to the presence of special cells. The outer margin of the leaf blade is wavy or scalloped. This permits the leaf to turn from the wind like a windmill out of gear, and thus to avoid throwing too great a strain on the stem.

**78. Ear branch and shucks.** The shank on which the ear is borne represents a branch.

This is proved: (1) by its position in the angle between the stem and the leaf sheath; (2) by the fact that the shank has nodes similar to those of the main stem; and (3) by the fact that most of these nodes bear a shuck, or *husk*, which is only a modified leaf, as will be seen readily by noting that many shucks are tipped with a small leaf blade (Fig. 28).

It is supposed that the shank which now bears the ear was originally a long branch, and that shortening of the branches occurred both by man's and by natural selection. For example, the plants with the shortest branches would be the ones most likely to propagate their kind in nature, because these branches would break off less frequently before maturing the seed.



Fig. 28. — An ear of corn showing leaf blades on the tips of the shucks

**79. Number of ears.** The number of ears on a plant varies greatly, according to the race of corn, the variety, the soil and fertilization, and the character of the season. In the ordinary, or *dent*, varieties the number seldom exceeds three and is more frequently one or two ears.

Many experiments have indicated that in the South those varieties of dent corn are most productive of grain that ordinarily bear two ears to the plant.

**80. Position of the ears.** Large yields of corn are made from varieties bearing ears at a medium height from the ground, while equally large yields are secured from other varieties, the ears of which are borne at a greater distance



*Courtesy Illinois Agricultural Extension*

**Fig. 29.** — Corn bred for high ears (left) and for low ears (right)

above the ground. Other things being equal, a moderate height for the ears is preferable. Among the advantages of a low or medium position are: (1) a decreased tendency for the ear to pull the plant down and (2) greater ease in harvesting. See Fig. 29.

**81. Tassel.** The tassel consists of a panicle, or spreading terminal flower cluster.

The tassel carries the male, or pollen-bearing, flowers, which are usually in groups of two flowers in a spikelet. Each flower, on maturing, pushes forth three anthers, or pollen cases, from which, when mature, the fine particles of pollen are set free to be borne by the wind to the silks of other corn plants. It has been estimated that a single tassel may bear more than 40,000,000 pollen grains.

The tassel usually appears two to four days before the first silks are visible on the same plant; this is a device to prevent the pollination of the silks by the pollen from the same plant.

Numerous experiments have shown that the removal of the tassels on half of the plants in a field does not materially influence the yield.



*Courtesy U. S. Dept. of Agriculture*

**Fig. 30.** — Spaces on cob not filled for lack of pollen

This ear grew on a plant that stood alone.

**82. Silks.** Each silk originates where a grain should be borne on the cob, from which position it grows until its outer part reaches the air beyond the tip of the shuck. This free part of the silk is supplied with very minute hairs, the purpose of which is to entangle and hold the grains of pollen. In case a silk fails to receive pollen, it may continue to grow to unusual length. In case no pollen lodges on any particular silk, no grain is formed at its point of attachment to the cob (Fig. 30).

**83. Pollination.** Pollination is the transfer of pollen to the sticky surface of the stigma, which in this case is the silk. Along the entire length of the silk grows the pollen tube (Fig. 31), thrown out by the pollen grain after lodgment on the silk.

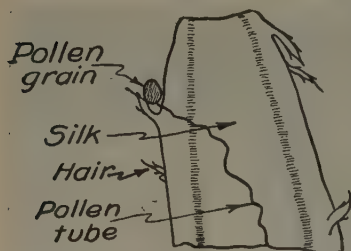


Fig. 31. — Section near outer end of a corn silk

Showing lodged pollen grain and its penetrating pollen tube.

The pollination of corn is effected almost entirely by the wind, which may carry the pollen great distances. Hence, fields of two different varieties of corn, which the farmer desires

to keep unmixed, should not be planted at about the same date within less than half a mile of each other, unless there are intervening woods or other obstacles.

**84. Impregnation, or fertilization, of the grain.** The word "fertilization," as used in this paragraph, does not refer to the supplying of food or fertilizing material to the plant. Fertilization of the flower consists in the growing of the pollen tube along the entire length of the silk and into the embryo sac (Fig. 31), and its union there with the egg cell of the mother plant to produce the seed (Fig. 32). Without such a union, no seed is formed.

After the pollen grain has lodged on the sticky surface of the protruding end of the silk, it grows into that silk and through its entire length to the point where the silk originates. There the pollen tube enters the embryo sac and sets free two male nuclei. One of these unites with the egg cell, effecting true fertilization and producing the *germ* (87) of the grain. The other male nucleus unites with the nucleus of the endosperm (Fig. 32). When this second union occurs, the result is an *endosperm* (87) that derives its qualities from the pollen-bearing parent as well as from the mother plant.

It is this second union, or double fertilization, which occurs in some plants, that enables the pollen of a yellow variety of dent corn to produce yellow kernels a few weeks after fertilizing the silks of a white variety. This is because the yellow quality has been given by the male parent to the endosperm, or main part of the grain, which color shows as yellow through the transparent hull or bran that covers the grain.

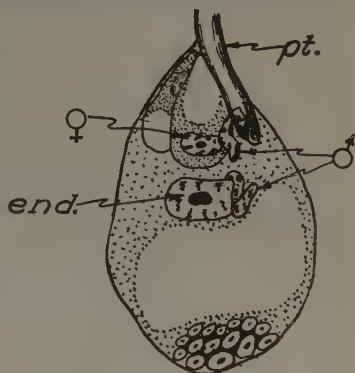


Fig. 32. — The embryo sac in corn at the time of fertilization

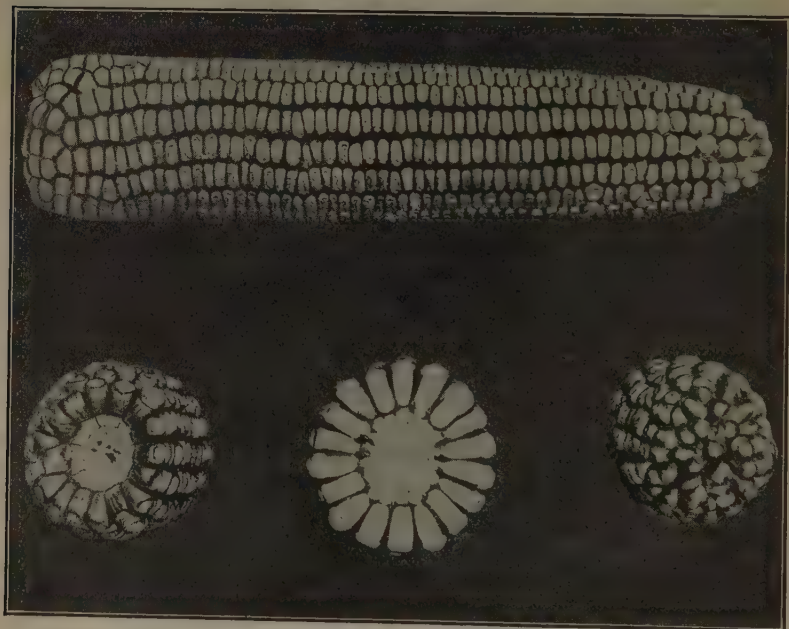
*pt.*, pollen tube which has just discharged 2 male nuclei,  $\delta$ ;  $\eta$ , egg-cell which, after union with one of the male elements, forms the germ; *end.*, nucleus of the endosperm, with which the second male nucleus may unite. (After F. E. Lloyd.)

**85. The ear.** There is great variety among ears in length, diameter, and number of rows of grain. A good ear of dent corn should bear about a thousand grains, usually in fourteen, sixteen, or eighteen rows (Fig. 33).

The number of rows is always even because an ear is made up of a number of branches, now united into a

single cob but once separate, each bearing two rows of grains.

The best ear is one having a cob not extremely small since this would not allow a sufficient number of rows. Neither should the cob be very large since this tends to late maturity and to the rotting of the ear in a wet autumn.



*Courtesy International Harvester Co.*

Fig. 33. — A well-shaped ear

Note that tip and butt are well filled. It may be criticised because the cob is rather small, the kernels narrow, and the space between the kernels slightly large. Compare with Fig. 39.

### STRUCTURE OF THE GRAIN, OR KERNEL

86. Shape. The kernel varies greatly in shape and size with the different races of corn. There are even great differences within the same variety and on the different

parts of the same ear. In the dent varieties practically all of the grains are flattened and somewhat wedge-shaped, their smallest diameter being the one parallel to the cob.

**87. The structure of the grain.** The grain is made up of a number of parts having distinct functions and separate origins. As a means of simplification, these are here grouped into three parts:

- (1) the chit, or germ, or embryo;
- (2) the endosperm, or main bulk of the grain;
- (3) the seed coats, or bran.

The embryo is situated at the cob end of the grain, under the depression, or groove, which faces the tip of the ear. It comprises about one eighth of the weight of the grain and is especially rich in fat.

The endosperm is that large portion of the seed lying around and between the embryo and the several outer coats of the kernel. The endosperm constitutes about 73 per cent of the weight of the entire corn grain and consists chiefly of starch, but contains also some protein, ash, and other materials.

This starch is arranged in two ways, giving two very diverse appearances to the different parts of the same endosperm. When this starch is loosely arranged, the color of that part is a pure snow-white, and it has an opaque floury appearance. On the other hand, when it is in compact form, the appearance is that of a horny or nearly translucent substance, which is called the horny, or corneous, layer.

The coats of the kernel, which are usually removed together in the form of bran, are several in number.

**88. Judging the composition of the kernel by its cross section.** By cutting transversely through a grain of corn, one may judge of its probable richness in fat, in starch,

or in protein by the thickness of the several layers constituting the germ, the loose floury starch, and the compact horny starch (Fig. 34).

A large germ (Fig. 35) indicates a high percentage of fat, which is important when the corn is used for the manufacture of corn oil. A thick layer of the loose floury ma-

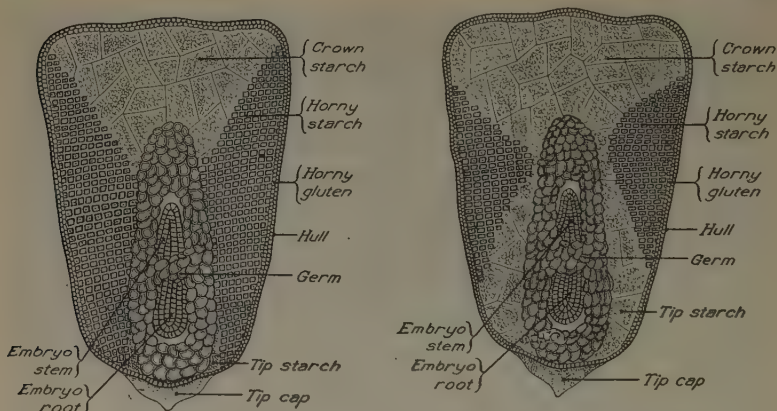


Fig. 34. — High-protein corn kernel (at left) and low-protein corn kernel (at right)

terial indicates a high percentage of starch. Unusual thickness of the horny layer implies a relatively high percentage of protein; for this compact layer, though composed chiefly of starch, is also comparatively rich in protein.

Analysis shows little difference between varieties, even when they vary considerably in the appearance of cross sections of their grains.

There is probably no necessity for the Southern farmer to select corn with special reference to increasing the yield of protein or of fat, for it is easy for him to grow legumes for feeding with corn to supply its deficiency in protein. The manufacture of corn oil is not important in the South.

**89. Location of the color in the corn kernel.** It is important to learn in what layer the color is located in the different classes of corn so that one may understand that part of corn breeding which relates to the heredity of the color of the grain.

The hull, or bran, of the grain of white and yellow varieties of dent corn is colorless or translucent; hence the color of white or yellow grains lies deeper; namely, in the endosperm. The pollen from a yellow variety may promptly, or in the current cross, give a yellow color to the endosperm of the cross-pollinated grains of a white variety. The yellow endosperm shows through the transparent hull and the grain appears yellow.

On the other hand, the red color sometimes appearing in dent varieties is due, not to a colored endosperm but to red color in the hull. Hence the red in the hull obscures whatever color there might be in the endosperm (*e.g.*, yellow) and determines the color of the grain. However, the pollen does not in the current cross affect the hull, so that impregnation of white grains by pollen from red varieties does not, like the use of yellow pollen, appear a few months after fertilization, but must wait to show the red color of the male parent in the next generation.

The color that is responsible for the blue, purple, or lead-colored appearance of certain kinds of sweet and soft corns, which are different races from ordinary, or dent, corn, is located in the outer part of the endosperm, or just be-



Fig. 35. —

Corn grains showing difference in germ, or embryo, which is large (upper row), medium (center), and small (bottom)

neath the hull. The color, being in the endosperm, is subject to double fertilization, and hence to the immediate display of the color of the pollen-bearing parent. A lead-colored corn planted near a white may immediately cause colored grains to appear on white ears all over the field.

### LABORATORY EXERCISES

#### Roots:

(1) Plant ten grains of corn 1 inch deep and other similar lots at depths of 2, 4, and 5 inches below the surface, either in a box of soil or in the garden or field.

(a) Record the number of days after planting before each plant appears.

(b) In about four weeks dig some plants resulting from each depth of planting, making drawings showing the position of the principal roots developed from each depth of planting.

(2) Carefully dig well-grown or even mature corn plants, washing the earth from around the roots.

(a) At what distance below the surface do most of the roots originate?

(b) Count and record the number of main roots.

(c) From how many of the joints do the true roots and brace roots spring?

(3) Make two sketches, one showing: (a) location of main roots where corn was planted in a furrow and earth subsequently thrown to it, and (b) location of main roots on a plant which has not been planted in a trench or had earth thrown to it.

#### Brace roots.

(4) On well-grown corn plants or on old cornstalks, examine the brace roots, noting (a) their number; (b) number of nodes from which they spring; (c) diameter just above the ground; and (d) diameter 1 or 2 inches below the surface.

#### Stems.

(5) Examine the bent portion of a number of well-grown corn plants or old cornstalks which have been blown down and subsequently straightened, to discover how the plant effected this bending by growing more rapidly on one side than on the other. Make a sketch of one such uneven node.

(6) Strip the leaves and leaf sheaths from a cornstalk and record the

length of (a) the lowest internode; (b) the internode just below the shank of the lower ear; and (c) the internode next to the tassel.

(7) Record the total number of internodes and their average length on (a) a tall plant and (b) a low plant in the same field.

#### Leaves.

(8) Record the number of leaves on an average corn plant.

(a) In how many vertical ranks are these arranged?

(b) Measure the midrib of an average full-grown leaf and the margin of the same to determine how much longer the margin is.

(c) By moving the leaves about, try to ascertain how the margin helps the leaves to avoid the pressure of the wind.

(d) Measure the approximate surface in square inches on the two surfaces of a grown corn leaf of average size.

(e) From (8) and (8d) calculate the probable number of square feet of leaf surface on 4000 corn plants borne on an acre.

#### Ear shanks.

(9) Record the number of nodes between the main stem and cob on a long ear shank; also the average length of five short ear shanks bearing mature ears. Do most of the ears point up or down?

#### Grains.

(10) (a) Soak grains of corn and separate the coats, the germ, and the endosperm.

(b) Cut crosswise through a number of kernels of dry corn and compare them as to thickness of the horny layer and as to size of germ.

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## CHAPTER V

### CORN — COMPOSITION AND JUDGING

The composition of dent and of flint corn, and of yellow and of white varieties of dent, is practically the same. The corn grain contains a large proportion of carbohydrates, or starchy material, which constitutes its chief value as food. The percentage of protein is so low that for some classes of live stock corn should be fed in connection with some food rich in protein. This is especially true for growing pigs, for working teams, and for poultry. Useful foods for feeding with corn are the following:

To growing pigs: skim milk, soy beans, cowpeas, dried blood, tankage, and pasturage consisting largely of the clovers and related plants.

To horses: hay of the clovers, alfalfa, cowpea, vetches.

To poultry: beef scrap, cowpeas, and fresh bone.

#### COMPOSITION

**90. Composition of corn and its products.** The following figures represent the average of American analyses:

TABLE V. COMPOSITION OF CORN

	WATER (Per cent)	ASH (Per cent)	PROTEIN (Per cent)	CRUDE FIBER (Per cent)	NITROGEN- FREE EXTRACT (Per cent)	FAT (Per cent)
Grain, dent varieties	10.6	1.5	10.3	2.2	70.4	5.0
Grain, flint varieties	10.3	1.4	10.5	1.7	70.1	5.0
Corn blades . . .	30.0	5.5	6.0	21.4	35.7	1.4
Corn stover . . .	40.1	3.4	3.8	19.7	31.9	1.1
Corn fodder . . .	42.2	2.7	4.5	14.3	34.7	1.6
Corn silage . . .	79.1	1.4	1.7	6.0	11.1	0.8
Corn bran . . .	9.1	1.3	9.0	12.7	62.2	5.8
Husks (shucks) .	17.2	3.2	4.3	29.5	44.9	1.0

**91. Parts of the corn plant.** *Corn stover* is the residue of stalk, leaf, and shuck after the removal of the ear. *Corn fodder* is the entire plant when grown thickly and cured for forage. *Corn blades*, very generally known in the South simply as “fodder,” are the leaves stripped from the plant just before the ears mature. The blades make a very



*Courtesy International Harvester Co.*

**Fig. 36. — Filling the silo**

palatable and nutritious food, but the yield is small, the labor of harvesting considerable, and the stripping of the blades reduces the yield of grain.

Corn stover, when shredded, has somewhat the same value as cottonseed hulls. The composition of the stover, however, is superior but the hulls mix better with concentrated foods and are eaten with much less waste. Stover should be fed in connection with cottonseed meal or other food rich in protein.

*Corn silage* consists of the entire plant cut, while still green but after the roasting-ear stage, into short lengths and stored in a silo. Here it keeps, with but slight loss, in green, succulent condition until winter. This is the best way to utilize the corn crop for dairy cattle and often for fattening cattle. See Fig. 36.

**92. Proportion of parts in the corn plant.** The Georgia Experiment Station (*Bulletin* No. 30) found that in every 100 pounds of the above-ground part of the corn plant, after being thoroughly air-dried,

grain constituted . . . . .	38.8 per cent	shucks . . . . .	11.1 per cent
stalks . . . . .	29.3 per cent	tassels . . . . .	1.3 per cent
blades . . . . .	9.8 per cent	and cobs . . . . .	9.7 per cent

**93. Corn products.** From the corn plant are made great numbers of products. Among those manufactured from the grain are corn meal, grits, hominy, and corn flakes — all used for human food; also corn oil, glucose, starch, and many others; and for stock feed, gluten meal, corn hearts, corn bran, and others.

The pith of the stalk is used as a packing material in the construction of warships. From the stalk cellulose is manufactured. All parts of the plant are used as food for live stock.

**94. Draft on soil fertility.** A crop of 40 bushels of corn and 3000 pounds of stover removes approximately the following amounts of plant food:

TABLE VI. PLANT FOOD REMOVED FROM THE SOIL  
BY A CORN CROP

	NITROGEN (Pounds)	PHOSPHORIC ACID (Pounds)	POTASH (Pounds)
40 bushels grain . . . . .	37.0	15.9	12.8
3000 pounds stover . . . . .	18.3	11.4	32.7
Total in grain and stover . . . . .	55.3	27.3	45.5

From the above table it may be seen that every bushel of grain removes about one pound of nitrogen, two fifths of a pound of phosphoric acid, and about one third of a pound of potash.

These figures impress the need of the corn plant for nitrogen, which is most economically supplied in manure or in a preceding soil-improving, or leguminous, crop, such as vetch, crimson clover, cowpeas, or velvet beans.

It should be noticed that the stover removes about three times as much potash as does the grain; and also practically half as much nitrogen. Hence the removal of the stover greatly increases the need for nitrogen and potash in the fertilizer for succeeding crops.

### JUDGING CORN

**95. Score card.** The object in judging ears of corn is to select the best seed corn. Various score cards have been



**Fig. 37. — Ten-ear sample of corn**

This is a good sample of market, exhibit, or seed corn.

devised as helps in selecting the best ears by applying a scale of points to the different features.

The score cards in use in different states vary somewhat. Their purpose is to direct attention in turn to each of the points of merit or demerit of each ear. A perfect ear, if such an ear existed, would score 100 points. Deductions, or cuts, are made according to the amount of deficiency in any quality.

In the following table are printed for reference score cards used in several of the Southern and Western States:

TABLE VII. SCORE CARD FOR JUDGING CORN

	ALABAMA	TENNESSEE	MISSOURI	MISSISSIPPI	TEXAS	ILLINOIS	KANSAS	OHIO
1. Uniformity . . . . .		10	10	5	10	5	10	
2. Maturity and market condition . . . . .	10	5	15	10	10		5	
3. Purity as shown by color of kernel . . . . .	5	10	5	5	5	10	10	10
4. Purity as shown by color of cob . . . . .	4		5	5	5			
5. Shape of ear . . . . .	10	5	5	10	10	10	5	10
6. Butts . . . . .	3	5	5	5	5	5	5	5
7. Tips . . . . .	3	10	5	5	5	5	10	5
8. Space between rows . . . . .	5	10		5	5	5	10	
9. Per cent grain to ear . . . . .	10	20		10		10	20	10
10. Trueness to type . . . . .	10			10		10		10
11. Space between kernels at cob . . . . .	5			5		5		10
12. Grain — (a) shape . . . . .	10	5	10	10	5	5	5	5
(b) uniformity . . . . .	5	5	5	5	5	5	5	5
(c) germ . . . . .			15		10	10		20
13. Length of ear } Weight of ear . . . . .	20	10	10	5	10	10	10	5
14. Circumference } . . . . .		5	5	5	5	5	5	5
15. Size of cob . . . . .			5		10			
	100	100	100	100	100	100	100	100

### LABORATORY EXERCISES

#### Practice in scoring ears of corn.

Each ear, or each exhibit of ten ears, should be scored by the score card used in the state nearest the students' home or by any other score

card that may be preferred. Let each student, after noting the excellencies and defects of all ears shown in class, score a number of ears of corn, entering the figures representing his estimate of each quality in the proper space in a table ruled or printed like the table on the preceding page.

The following paragraphs indicate some of the most important considerations in scoring each character:

(1) **UNIFORMITY.** The ear examined should be like other ears of the same variety, and all ears of one exhibit should be uniform in size and appearance (Fig. 37).

(2) **VITALITY, MATURITY, AND MARKET CONDITION.** Good germinating power and market condition are shown by the soundness of the grain and freedom of the tip of the grains from dark spots, adhering particles of husk, shriveled appearance, or undue slenderness at the tip near the cob. Germination tests may be made.

(3) **COLOR OF GRAINS.** All grains on an ear should be of the same color.

(4) **COLOR OF COB.** A white cob is preferred for white varieties. Most score cards prescribe that a yellow variety shall have a red cob. This, however, is merely a fancy point. The color of cob should be uniform for every ear in an exhibit.

(5) **SHAPE OF EAR.** It is generally assumed

that a nearly cylindrical shape is best; but at the Ohio Experiment Station tapering ears were quite as productive as cylindrical ears. The ear should be straight and even, without undue swelling at the butt, and the rows should be straight (Fig. 38).

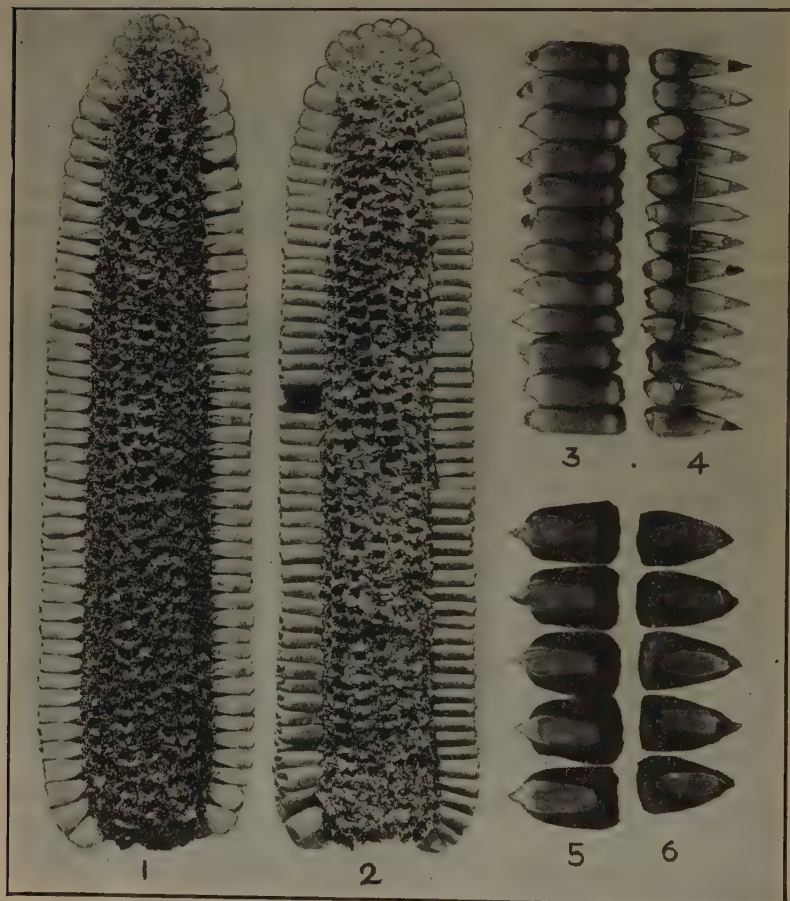


*Courtesy International Harvester Co.*

**Fig. 38.** — Variation in size and shape of kernels and in straightness of rows

Such ears as the two middle ones should be discarded in selecting seed corn.

(6) BUTTS OF EARS. The grains on the butts should project slightly and evenly beyond the cob, forming an even, well-rounded butt, with grains not very variable in shape and size. The place of attachment of



*Courtesy International Harvester Co.*

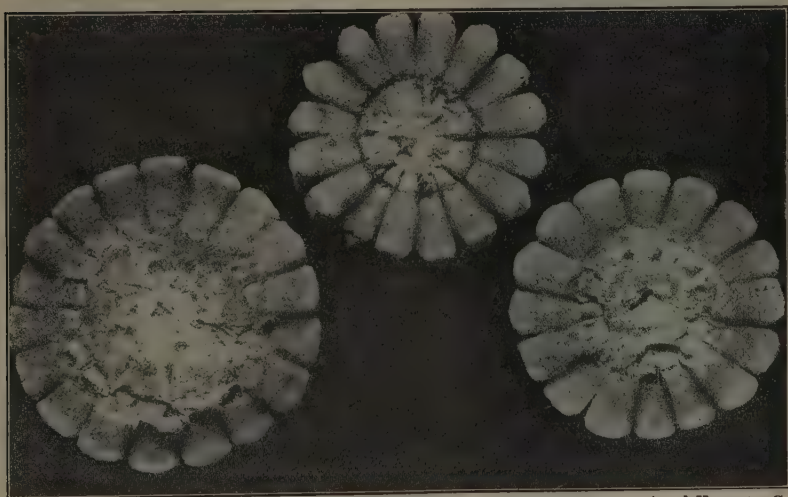
Fig. 39. — Shape of kernels and space between

Ears 1 and 2 are nearly alike in size and shape but No. 2 shelled out one third more corn than No. 1. Rows 3 and 5 are from No. 2 and rows 4 and 6 are from No. 1.

the ear shank should be of moderate diameter and free from discoloration or other evidence of disease.

(7) TIPS OF EARS. The grains should as nearly as possible hide the cob at the tip and should there be of fair size. Some authorities regard a well-covered tip as rather a fancy point, while others consider it as closely related to a high yield. For the Cotton Belt it is important that the tip be well protected by tightly fitting husks.

(8) SPACE BETWEEN ROWS. The spaces (furrows), or *sulci*, are the depressions between adjacent rows of grain near the crown of the kernel.



*Courtesy International Harvester Co.*

Fig. 40. — Cross sections of three ears

The ear at the top is poor — the cob being small and the kernels too far apart; the left-hand ear has too large a cob and too shallow kernels; the right-hand ear is a good ear.

The deeper and wider these spaces are, the more defective is the ear in this respect since deep furrows imply rounded grains with a low percentage of grain to cob.

(9) PROPORTION OF CORN ON EAR. Medium to small cobs and long grains indicate a high percentage of corn and are desirable. A cut, or deduction, may be made where the shelled grain constitutes less than 86 per cent of the husked ear.

(10) **TRUENESS TO TYPE.** Every ear should possess the qualities common to that variety.

(11) **SPACE BETWEEN KERNELS NEAR COB.** One judges this by removing several rows of grains and viewing the remaining rows from a position showing the edges of the kernels (Figs. 39, 40). Much space between the grains near the cob indicates grains of poor shape and an ear of low percentage of grain, and sometimes this also indicates immaturity.

(12) **KERNELS** (Figs. 39, 41). The best shape is a cut-off wedge, the edges of the grain touching the adjacent row throughout nearly its whole length. The shoulders near the tip should be broad and plump. The kernels should be long and free from an excessive amount of *beak*, or shriveled portion at the crown. Excepting those at the extreme butt and tip, the grains should be of uniform size and shape and of nearly uniform denting. The color of all grains on one ear should be identical. Yellow varieties should have grains free from white caps, and grains on white varieties should be free from a yellowish or amber tint.



Fig. 41. — Various shapes of corn kernels

Grains at top are well shaped; at bottom, too short and rounded; between, too pointed at base.

(13) **LENGTH OF EARS.** The preferred length is usually about one and one third times the circumference, being measured one third the distance from the butt. Yet this varies with different varieties.

(14) and (15) **LENGTH AND CIRCUMFERENCE OR WEIGHT OF EAR.** This refers to the weight of grain and cob after thorough air-drying. In most

score cards this is covered by measurement of the length and circumference of each ear. The standard, or ideal, should be a larger ear in the case of one-eared than in the case of two-eared varieties.

#### Practice in use of utility score cards.

Recently several utility score cards have been formulated, which are supposed to determine more accurately than did the score cards hitherto used the actual value of corn for planting.

Pupils may practice judging first by the preceding system. Then after having conducted germination tests of grains from ears to be further scored, they may apply the utility score card.

## ILLINOIS SCORE CARD FOR UTILITY CORN

	PERFECT SCORE	SCORE OF SAMPLE No.	SCORE OF SAMPLE No.
<b>General appearance:</b>			
Indentation (not very rough) . . . . .	5		
Kernel composition (not very starchy) . . . . .	5		
Kernel characteristics (bright, thick, plump; large germs) . . . . .	10		
Shank attachments (not pink, brown, or shredded) . . . . .	10		
Tips of ears (bright, not discolored) . . . . .	5		
Luster or polish (oily appearance) . . . . .	10		
<b>Type and uniformity:</b>			
Type (uniform kernels) . . . . .	5		
Length of ear . . . . .	5		
Color (uniform) . . . . .	5		
General uniformity (ears alike) . . . . .	5		
<b>Germination record:</b>			
Vitality and vigor of sprouts . . . . .	20		
Freedom from disease symptoms near cob . . . . .	15		
Totals . . . . .	100		

**Composition of grains.**

- (1) From a crib of corn select:
  - (a) Two ears having a high percentage of protein, as shown by thickness of horny layer (88) in grains near the center of the ear;
  - (b) Two ears having a low percentage of protein; and
  - (c) Two ears having a high percentage of fat.
- (2) Make drawings of cross section of three grains representing the ears selected under (a), (b), and (c).

**ADVANCED TOPICS**

A. A laboratory determination of the proportion of the total air-dry weight of the corn plant made up separately by grain, leaves, stems, shucks or husks, cobs, etc.

B. A library study of the composition of the various parts of the corn plant.

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## CHAPTER VI

### CORN — RACES AND VARIETIES

Maize has varied into almost numberless forms, ranging from the tall corn of the Southern States to the dwarf of high latitudes, and has given rise to many shapes and sizes and colors of kernel and ear. Some corn is very early, some late; some kinds have flinty kernels, and others have very soft grains.

**96. Races of corn.** Corn is divided into at least six great divisions, or races, which cross freely with each other. These races are: (1) dent, (2) flint, (3) sweet, (4) pop, (5) soft, and (6) pod corn. These races are distinguished by differences in the structure of the grains (Figs. 42, 43) as well as by other distinctive characters.



Fig. 42. — Races of corn; cross section through kernels

Dent corn comprises all the varieties commonly grown in the fields in the Southern States. Indeed, the bulk of the American corn crop belongs to this race.

(1) In *dent corn* a cross section of the grain shows that the floury or soft part, consisting chiefly of loosely arranged starch grains, comes quite to the top of the grain. The shrinkage of this soft loose starch during ripening causes the depression, or dent, which gives the name to the race. The grains of dent corn are usually much flattened and wedge-shaped and longer or deeper than broad. The plant may be small, medium, or very large, Southern varieties being almost invariably large.

(2) In *flint corn* the layer of soft loose starch does not come to the top of the kernel but is surrounded, over the top as well as on the sides, by a horny layer, which is also made up chiefly of starch, compacted into a dense, almost translucent mass. The difference between the horny and the loose starch has been likened to that between ice and snow. The complete arch of horny starch over the top of the grain insures the ripening of the kernel without uneven shrinking or denting. The grains of flint corn are usually less flattened, shorter, and more rounded, and they are smooth over the top and thicker than dent corn.



Fig. 43. — Races of corn; longitudinal section through kernels

A, dent; B, flint; C, sweet; D, soft; and E, pop.

The stalks are usually small, and the ears are borne near the ground. The varieties of flint corn mature quickly and are best adapted to regions near the northern limits of corn production. In the South they are little grown and comparatively unproductive.

(3) *Sweet corn* may be known by its wrinkled, horny grain, due to the presence of sugar in the endosperm, and by the absence of floury white starch. The plant is very small and bears many small ears (Fig. 50), which mature early. Sweet corn is generally grown in Southern gardens, but is less productive here than in higher latitudes.

(4) *Pop corn* may be recognized by the entire absence of floury starch, the whole endosperm being compact and

horny. This compactness explains why the grain swells or pops so completely. The plant is extremely small, the ears numerous and of diminutive size, maturing early.

(5) *Soft corn* bears a grain in which all of the endosperm is soft and white. This is the original kind cultivated by the Indians. It suited their needs by reason of the ease with which it could be ground. It is not now cultivated to any extent in the United States. The ears are small (Fig. 44), and the grains usually small, rounded, and without dents.

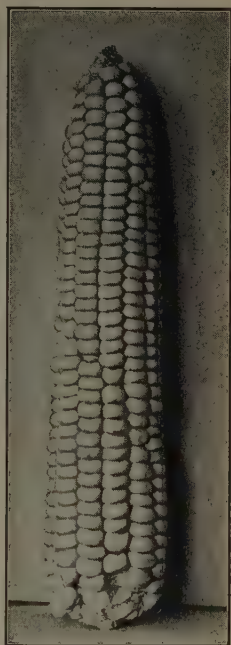


Fig. 44. — Ear of soft corn



Fig. 45. — Ear of pod corn

a race of any value. Each single grain is inclosed by small shucks, while the whole ear, or collection of grains, is wrapped in an outer shuck (Fig.

45). This is probably nearer to the original form of the plant than are any of the other races.

**97. Characters needed in Southern varieties.** Varieties of field corn in the South must be chosen within the dent

race. The primary consideration is a large yield of grain per acre. Among the other desirable qualities of a variety for the South are the following:

(1) Medium or late maturity, in order to secure a maximum yield and to escape the great injury done to the early varieties by grain weevils.

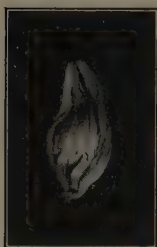


Fig. 46.—Single grain of pod corn, inclosed by tiny husks

(2) At least a medium degree of hardness of kernel, to avoid the excessive injury inflicted by weevils on varieties with very soft grains.

(3) Tight and complete covering of shuck around the tip of the ear, to retard the entrance of weevils and to prevent injury from wet weather (Fig. 47).

(4) Ears falling or bending down, so as to escape severe injury from wet weather.

(5) Ears at medium height from the ground, so that the stalk may not be blown or pulled down so easily as when the ears are high.

(6) Small or medium-sized cobs, to decrease the danger from rotting in the field or in the crib.

(7) Ear shank of only moderate length and size.

(8) Uniformity in character of plant and ear, this being usually an indication of purity and of careful breeding.

**98. Qualities accompanying a high yield.** The following characteristics usually accompany large yields of grain in varieties adapted to the South:

(1) A tendency to produce two ears per stalk.



Photo by W. E. Hinds  
Fig. 47.—An ear with tip well covered by shucks

(2) A small or medium-sized cob, long grains of a wedge shape, and a rather high percentage of grain.

(3) Medium or late maturity.

**99. Color of grain.** The color of the grain is not of importance in the case of a variety intended for stock food. However, for the making of corn meal, the Southern markets prefer white corn.

The color of the grain does not affect the chemical composition though yellow corn is richer than white varieties in vitamins. But in well-proportioned mixed rations white corn is doubtless equal to yellow in feeding value. Color probably has no relation to yield.

More than 1000 names of varieties have been listed. Many of these are merely names for the same variety.

**100. Yields of varieties.** An examination of the yields of corn made in variety tests at Southern Experiment Stations shows that there is no one best variety of corn for all conditions of soil and climate, even within the limits of the Cotton Belt. However, it appears that in the greater number of experiments, but by no means in all, the most productive varieties belong to the class of prolific corn; that is, corn having a tendency to produce from 160 to more than 200 ears for each 100 plants.

For example, in four years' tests at the Alabama Experiment Station, the prolific varieties averaged 33.8 bushels per acre; the varieties of medium prolificacy averaged 27.7 bushels; and the nonprolific varieties averaged only 27 bushels. If from the two latter classes all the early Northern varieties, which have proved decidedly unproductive in this climate, should be excluded the yields of the three classes would come closer together, but the average would still favor the prolific kinds. In North Carolina some prolific variety usually led in productiveness.

The following are the varieties which have averaged highest in productiveness at the Southern Experiment Stations in recent years, as reported by correspondence early in 1924:

STATE OR STATION	VARIETY
Alabama . . . . .	Whatley      Marlboro Weekley      Mosby Hastings      Pee Dee
Arkansas (Northern) . . . . .	Neal Paymaster Boone County
(Bottom Lands) . . . . .	Mosby      Cocke      Hastings
(Southern) . . . . .	Delta      Valentine
Georgia (Athens) . . . . .	Whatley      Hastings Marlboro
Georgia (Experiment) . . . . .	Garrick      Piedmont Whatley      Marlboro Hastings
Kentucky . . . . .	Boone County White Johnson County White Pride of Saline Reid Yellow Dent St. Charles White Tennessee Red Cob
Louisiana (Northern) . . . . .	Calhoun Red Cob Hastings Mosby Sentell White Dent Whatley
(Central) . . . . .	Calhoun Red Cob Hastings Mosby Whatley Yellow Creole
(Southern, Gulf Coast) . . . . .	Yellow Creole
(Southern Reclaimed Lands)	Imperial White

STATE OR STATION	VARIETY
Mississippi . . . . .	Cocke            Whatley Mosby           Neal Paymaster Hastings
North Carolina (Coastal Plain) .	Biggs            Latham Cocke Indian Chief (yellow)
(Piedmont Section) . . . . .	Southern Beauty Weekley        Grampain Petries Jarvis Golden Prolific (yellow)
(Mountain District) . . . . .	Shoaf            Cocke Biggs            Hollecombe Southern Beauty Jarvis Golden Prolific (yellow)
Oklahoma Silver Mine . . . . .	Reid Yellow Dent
(Western) . . . . .	Squaw (soft)
South Carolina . . . . .	Douthit        Garrick Hastings
Tennessee . . . . .	Neal Paymaster
(for elevated regions) . . . . .	Piedmont White Dent
(for the poorer soils) . . . . .	Jarvis Golden Prolific (yellow)
(for silage) . . . . .	Albemarle and Cocke
Texas . . . . .	Chisholm        Sure Cropper Fentress Strawberry Thomas Ferguson Yellow Dent
(for eastern Coastal Plain) .	Tuxpan
Virginia (Western) . . . . .	U. S. Selection 182 Silver King    Leaming
(Middle and Tidewater) . . .	Virginia White Boone County Reid Yellow Golden Standard

**101. Southern varieties by classes.** Among productive varieties belonging to the prolific type are the following:



**Fig. 48. — Mexican June corn**

Albemarle	Mosby
Biggs	Sanders
Cocke	Weekley
Hastings	Whatley
Marlboro	

The cobs are small, the ears small, and the grains usually rather long and slender.

Among the large-eared varieties with red cobs are:

Henry Grady
Tennessee Red Cob
St. Charles White

Among the early-maturing varieties, but not extremely early, and better suited to the South than most earlier sorts are the following:

Cocke (some strains)
Hickory King
Blount Prolific
St. Charles

Mexican June corn is in a class by itself. It is chiefly valuable for late planting because of its strong root and leaf systems and its notable endurance of the heat and drought of late summer. The stalk grows to immense size, usually 10 to 12 feet. The stem is of large diameter and rich in sugar. It has a small white ear with soft grains and is not very productive of grain (Fig. 48).

### LABORATORY EXERCISES

#### Races.

Make drawings from nature of the cross section of the grains of as many races as can be found, especially dent, flint, pop, and sweet corn.

#### Main characteristics of varieties.

Study and write descriptions of as many as practicable of the most important Southern varieties, recording especially:

- (a) habit of bearing one or two or more ears;
- (b) form of ear;
- (c) shape and size of grain;
- (d) size and color of cob.

### ADVANCED TOPICS

A. A statistical study of results of corn-variety tests at the Experiment Stations having soil and climatic conditions somewhat similar to those of your state.

B. A local corn-variety survey and a collection of the experiences of local farmers with various varieties.

### REFERENCES

- United States Department of Agriculture, Office Experiment Stations,  
*Bulletin*, No. 59.  
Alabama Experiment Station *Bulletins*, Nos. 111, 134, 200.  
North Carolina Board of Agriculture *Bulletin*, Vol. 29, No. 2, and later.  
North Carolina Experiment Station *Bulletins*, Nos. 204, 256.  
Mississippi Experiment Station *Bulletin*, No. 198.  
South Carolina Experiment Station *Bulletin*, No. 207.  
Tennessee Experiment Station *Bulletin*, No. 89.  
Texas Experiment Station *Bulletin*, No. 276

## CHAPTER VII

### CORN — BREEDING OR IMPROVEMENT

Corn breeding is concerned with determining (1) what qualities of grain, ear, or plant are hereditary; (2) the best method of finding hereditary qualities; and (3) the means of improving or modifying hereditary qualities.

In other words, the plant breeder's task is to maintain desirable qualities now in existence and to add to them or so to combine them as to make subsequent crops more productive, or otherwise better suited to the farmer's needs.

**102. Improvement of varieties.** Corn is so easily cross-pollinated and mixed with inferior kinds (Fig. 49) that



Fig. 49. — Showing the immediate effects (in the current cross) of crossing a white pop corn (on left) with pollen from a yellow dent corn (on right)

The resulting hybrid ear with both white and yellow grains is shown in the center.

few of the so-called varieties are strictly pure or uniform. Indeed, until within the past few years but few attempts have been made in the South to improve varieties by breeding or even to keep pure the best existing sorts. Almost any local kind, now found to be productive and otherwise valuable in its special locality, is worth improving by careful and scientific methods of breeding.

The first effort of the breeder should be directed towards increased yield, to secure which he should select chiefly those plants which carry the greatest weight of grain. Next he should aim at uniformity and at the other qualities usually considered desirable. Rather than to attempt to create an entirely new variety by crossing two existing kinds, he should start with one existing variety that is nearest to his ideal or that best suits his local needs.

**103. Selection and crossing.** The plant breeder improves plants by two means: (1) selection and (2) crossing. Selection is generally more important for the breeder, and this is the only means of improvement that the average farmer can practice advantageously. Crossing occasionally serves a useful purpose in the hands of a skilled breeder; but it usually destroys uniformity and must always be followed by years of selection before its results become of practical value.

Selection of seed corn should be practiced by every farmer. It gives results even in the first crop.

**104. Qualities needing improvement.** Among the qualities for which selection should be made in developing varieties of corn for the Southern States are the following:

- (1) Increased yield.
- (2) Production of two ears per plant.
- (3) Improvement in the shape of ear and kernels.
- (4) More uniformity among kernels, ears, and plants.



Fig. 50. — Ear of sweet corn

Note white grains from cross with dent corn.

- (5) Increased closeness and firmness of grains on the cob.
- (6) Disease resistance and ability of the plant to stand erect.
- (7) Lower position of ears on the plant.
- (8) More complete covering of the tip by shucks.
- (9) Tendency for the mature ear to turn downward.
- (10) A decrease in the size of the plant in some varieties.

**105. Hereditary qualities.** Among the stalk characters which have been found to be hereditary are the following: height of plant; height of ear; length of shank; direction in which the mature ear points; number and width of blades; tendency to bear more than one ear; tendency to produce suckers; and ability of the mature plant to stand erect instead of being blown down. Practically all the peculiarities of ear and grain are hereditary.

**106. Height of ear.** It is desirable that the ear or ears be borne at a medium height above the ground. It has been found in breeding experiments (Illinois Experiment Station, *Bulletin* No. 132) that the height can be raised or lowered by selection with this definite end in view (Fig. 29). In the fourth generation the average position of the ears was twice as high when selection had been made for high ears as in the strain selected for low ears, the difference in height of ears being about three feet (Fig. 29).

Accompanying the lower position of the ears was earlier maturity, a decreased number of internodes and leaves, a decrease in the length of the internodes, and a decided diminution in the height of the plant.

**107. Angle of the mature ear.** The Illinois Experiment Station has determined (*Bulletin* No. 132) that the tendency for the mature ears to remain erect or to bend downward is an hereditary quality and that this tendency can be intensified by selection. The drooped ear, which is

preferable because of its increased protection against rain, was found to accompany a long shank. One strain had shanks averaging twelve inches in length, the other seven inches. The diameter of the shank did not, in this case, determine the direction in which the mature ear pointed.

**108. Barren plants.** Barrenness, or the tendency for a considerable proportion of the plants to bear no ear, is usually regarded as hereditary.

Hartley (United States Department of Agriculture *Year-book*, 1902, p. 549) found that the removal of barren stalks from the field where seed was saved reduced the percentage of barren stalks in the next crop from 8.11 to 3.43. Since barrenness is difficult to detect before tasseling, it is advisable to remove the tassels from all poor stalks before they shed any pollen, whether these plants are entirely barren or merely weak and poor. The remaining tassels will furnish an abundance of pollen.

**109. Influence of size of ears.** At the Virginia Experiment Station (*Bulletin* No. 165, p. 170), the crop from large ears averaged five bushels more per acre than that from small ears of the same strain. Likewise greater yields were obtained from large ears at the Ohio Station; the percentage of germination was higher for the grains on the larger ears, and the young plants from the larger ears grew more rapidly.

**110. Selection in the field better than in the crib.** Selection of seed ears can be made better in the field (Fig. 51) than in the crib, especially in the case of two-eared or prolific varieties. Selection in the crib tends to reduce the proportion of plants bearing two ears, and thus it may even be the means of reducing the yield. This is because in the crib the largest ears are chosen, and these are most frequently from plants that produced only one ear. Selection in the

crib is of more value when only one ear to a plant is desired. Even in this case crib selection may serve to perpetuate

plants with ears borne too high on the stalk or having other serious faults.

**111. Selection without an ear-to-row test.** Those who can not take the pains and time needed to plant an ear-to-row seed patch (113) will profit by paying to some one else even a high price for corn thus improved. Such seed corn should be bought on the ear, so that all the qualities of the ear may be known.



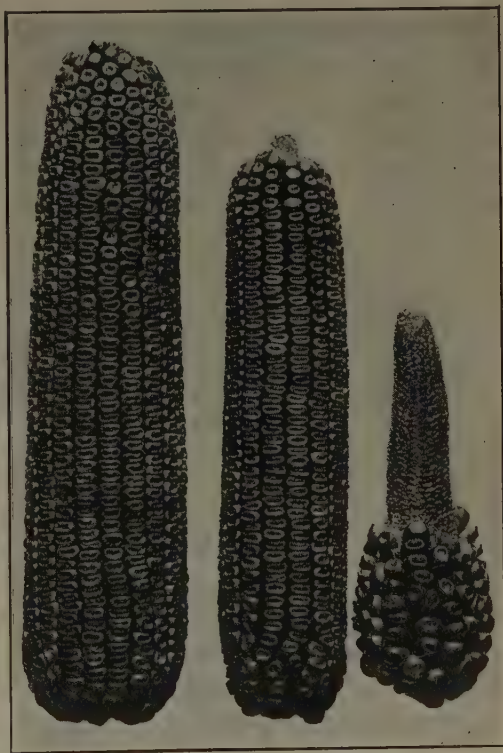
*Courtesy International Harvester Co.*

**Fig. 51. — The best place for selecting seed corn — in the field**

It may be possible to maintain the excellence of a variety, but scarcely to effect rapid improvement, merely by selecting in the entire field ears from the best and most productive plants. To do this, the farmer should himself go through his field before harvest time and in a bag or basket gather as many ears as will be needed for seed. When one is making these selections, the ears from the most productive plants should be harvested, but not from those the productiveness of which is due to richer soil, to unusual

distance from the next plant, or to other temporary advantage. Excellence due to these accidental causes is not transmitted to the next generation.

**112. Accidental *versus* inherited excellence.** Great improvement in the yield of corn may be effected through the process of selection with a view to identifying and propagating those individual plants that have strong hereditary qualities. The separation of such worthy individuals is by no means as easy as it may seem, for individual excellence may be due merely to favorable surroundings, such as extra space or heavy fertilization, in which case the superiority is not transmitted to the offspring. On the other hand, it may be due to inherent power in the plant itself, independent of environment; such inherent excellence is hereditary.



Courtesy International Harvester Co.

**Fig. 52.** — Ears from three adjacent plants  
The difference is due to the producing power of their  
parents — a strong argument for seed testing.

The breeder's first task, then, is to devise a system by which he can determine which plants are accidentally productive and which are in themselves superior. In other words, he must find which good plants are able to transmit their good qualities. This is best done by means of the ear-to-row system of field testing.

**113. Ear-to-row system.** This method consists in planting in one row only the seed from a single ear or from part of a single ear. At harvest time the yield of each row is determined separately. The best rows indicate which parent ear was best able to transmit its good qualities (Fig. 53). By selecting for seed the best plants on these



Fig. 53. — Relative yields of the same variety from two breeding rows of equal length

best rows, and again planting each ear on a separate row, improvement is rapid, provided the breeder, year after year, aims at the selection and perpetuation of the same good qualities. Moreover, since self-fertilization year after year causes corn to deteriorate, it is advisable to prevent this by removing, as soon as they appear, the tassels from the rows from which seed ears are to be selected.

In a breeding patch in which this system is pursued, the procedure should be as follows:

**114. Details of ear-to-row system of corn breeding.** Select about 100 of the best ears obtainable from the given variety. From these discard all except 48, or other large

number, of the heaviest, best, and most uniform. Secure very uniform land and lay off as many rows as there are ears to be planted, say 48, noting that the two ends of all the rows are of apparently uniform fertility.

On each row plant the greater part of a single ear, plac-

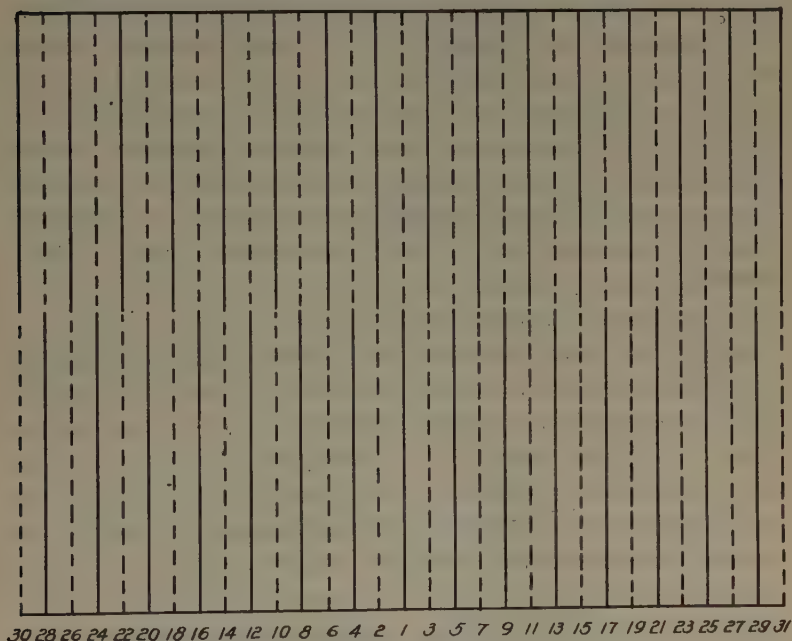


Fig. 54. — Diagram of rows in ear-to-row breeding plot

Dotted lines show rows from which tassels are removed.

ing the best ears near the center of the plot (Fig. 54). The rows should be of uniform width and of such length as to contain at least 150 hills, the hills being in checks at a uniform distance apart. If practicable, preserve until after harvest time the unplanted grains on each ear, as the best of these remnants may be needed for planting the next year.

Around the edges of this breeding plot plant the best ears not used in the breeding plot, these "general-crop rows" serving partially to exclude pollen of inferior plants and of other varieties. If practicable, let this breeding plot be at least a quarter or half of a mile from any other field of corn and preferably separated from any other corn by woodland.

If necessary, fertilize each half of each row with uniform weighed amounts of fertilizer.

As soon as the tassels show, and before they have discharged any pollen, remove the tassels on one half of every odd-numbered row (let us say the north half) and on the other (or south) half of every even-numbered row (Fig. 54). Seed is to be saved only from the detasseled plants, thereby insuring cross-fertilization.

From time to time as the crop grows, make note of and reject those rows on which the plants show undesirable qualities, such as excessive growth of suckers, tendency to fall down, excessive height of ears above ground, and the like. At harvest weigh the husked ears of each row separately and in each of the best ten rows place a label or tag on a number of ears from the best plants. On this tag should be entered the peculiar excellence, if any, of each selected plant.<sup>1</sup>

For planting the breeding patch of the second year, save the ears from the best plants on the eight or ten best rows. Use the remaining good ears from these best rows to plant larger fields next year. These steps are usually all that are necessary in the improvement of corn as far as most farmers are concerned.

The method of conducting the ear-to-row breeding plot is

<sup>1</sup>The limits of this book preclude an explanation of systems of numbering the ears and their offspring, for which the reader is referred to Illinois Experiment Station's *Bulletin*, No. 100; Connecticut Experiment Station's *Bulletin*, No. 152; and Bailey's *Cyclopedia of American Agriculture*, Vol. II, p. 424.

the same year after year, seed each year from the best plants of the eight to ten best rows being obtained. All other good ears from detasseled plants of the most productive rows may be used as seed for a seed patch of several acres or for the general crop.

**115. The multiplication plot.** The ears from the most productive rows inherit productiveness on the side of the female, or pistillate, parent; but the pollen that fertilized these ears may have come from one of the most inferior rows. In order to insure the best pollen, careful plant breeders sometimes take the additional step of planting each year a special multiplication plot, or mating area of corn.

In this they plant the remnants of the best original ears saved from the planting of the preceding spring. These original ears in the intervening year have shown their ability to transmit productiveness to their offspring. These remnants of ears are pure; that is, free from admixture of pollen from inferior strains.

Hence, most rapid progress in corn breeding is made by having in the second year an isolated multiplication, or mating, plot, in which are planted in alternate rows two or more of the best remnants of ears, as judged by the yields of the offspring of parts of the same ears in the ear-to-row test.

Half of the rows in the multiplication plot should be detasseled. Thus self-fertilization is avoided and the union by cross-fertilization of two productive strains is insured.

When it is feasible to plant such a mating patch, the ears from its detasseled rows constitute the seed for a seed patch of the third year, the product of which will plant the entire general crop of the farm, or will be sold for seed. Since special equipment of ventilated, insect-proof jars or cases is needed in the South to preserve the remnants of the original

ears for one year, most Southern breeders omit the mating plot planted with such remnants of ears.

**116. Breeding for composition.** Hopkins and Smith, at the Illinois Experiment Station (*Bulletins* Nos. 119, 128), have proved that the composition of corn can be varied by selection of seed ears. They selected for many years in succession kernels rich in the chemical constituent desired, fat, protein, or starch (Fig. 34). After continuing this work for a number of years, great variations were found in the resulting strains. For example, after ten years of breeding, the strain continuously selected for its high percentage of oil contained 7.37 per cent of fat, or nearly three times as much as the strain selected for a low percentage of oil.

In ten years the average percentage of protein in the grain was raised from 10.92 per cent at the beginning to 14.26 at the end of the decade. The high-protein strain was then nearly twice as rich in this constituent as was the strain continuously selected for a low percentage of protein. The high percentage of protein gives to corn a higher feeding value of a kind especially desirable when corn must be fed without being combined with other foods richer than itself in protein. Apparently this strain was less able to resist drought, making a lower yield in a dry year than did the low-protein strain. It is highly probable that the high-protein strain more rapidly exhausts the soil.

In breeding for a high percentage of protein, the breeder should not be deceived if the percentage of this constituent should run abnormally high in a very dry season, a result which Hopkins and Smith found to be due to the failure of the grain, under these conditions, to assimilate its usual quantity of starch.

The strain continuously selected in Illinois for low protein made larger ears and a larger yield of grain per acre than

the higher protein strain; likewise, the strain poor in fat generally yielded more grain per acre than the strain rich in fat and had larger ears than any other strain whatsoever. Its grains were broader, due to the larger proportion of starch, and consequently there was a smaller number of rows of kernels than on the ears of other strains.

**117. How to select grains according to composition.** Those kernels which, in cross section, show a large proportion of germ, are rich in fat; those with an abundance of horny material are rich in protein; while those with the greatest proportionate development of loose floury material are richest in starch. It has been found that the composition of the kernels of the entire ear is about the same as that of any row of grains on the ear.

**118. Germination test.** Care should be taken to select for planting only those ears on which nearly every grain will germinate. Among the signs of poor germination are a dark area near the tip of the grain and a shriveled tip; but many grains that appear to be sound fail to sprout.

Some farmers have found it profitable to test for germination every ear planted. The method used is the following:

The seed ears are spread out on the floor in order and a number attached to each by means of a small nail driven through a small paste-board label and into the butt end of the cob. Each ear is

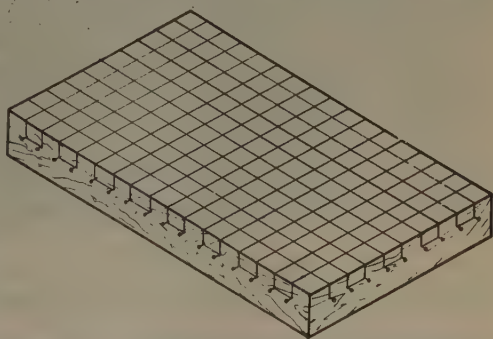
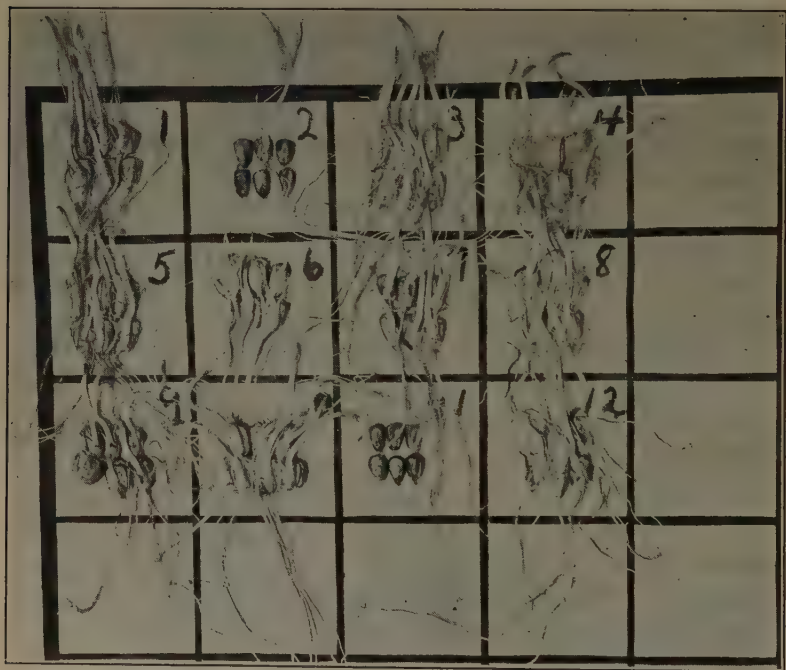


Fig. 55. — Germinator made from a soap box  
Filled with moist sawdust and divided into squares  
by strings.

given a number, and from each ear six or ten grains are removed, these being taken from different parts of the ear.

A germination box is made by taking any shallow box of proper size and placing in it two or more inches of damp



*Courtesy International Harvester Co.*

**Fig. 56. — Germination test of seed corn**

Ears 2, 6, 11 should be discarded and selection made from the others according to their vitality.

sand or damp sawdust (Fig. 55). The sand is covered with a white cloth, which is divided by pencil marks or string into squares two inches each way, each square bearing a number corresponding to the number on one of the ears. The six or ten grains taken from different parts of each ear are placed on the square bearing the same number as the ear. Another

cloth (or cloth bag containing damp sawdust) is laid over the squares containing the grains to be tested, and over this second cloth is spread about an inch of moist sand or damp sawdust. The box is placed in a warm room, and in seven to ten days a count is made to determine which ears sprout properly. No ear which bore a grain that failed to sprout should be used for planting. Those ears should also be rejected of which any sprouts show weak growth or discoloration, since these indicate weakness or disease.

**119. Crossing *versus* selection.** Crossing two distinct varieties results in variation (or a lack of uniformity) in the plants; uniformity may not again be established completely even after five or ten years of subsequent selection. Hence it is usually better for the farmer to improve his corn by selections among the individual plants of a single variety than to attempt to cross two dissimilar varieties.

However, since crossing in certain rare cases is advisable and since it often takes place accidentally, a few of the simpler effects of crossing are briefly discussed.

**120. Definitions of degrees of relationship between corn plants.** Self-pollination, or inbreeding, consists in placing the pollen of one plant on the pistil (silks) of the same plant. This relationship is too close for best yields, especially if the process be continued for several years.

Close-breeding consists in crosses made between the silks and tassels of plants all of which sprang from grains borne in the next preceding generation on one ear. This relationship is so close as to incur the danger of reducing the yield of grain.

Cross-breeding consists in crosses made between plants that are not related. This may be (a) between unrelated plants of the same variety; or (b) between different varieties of the same race, such as yellow and white dent corns; or

(c) between different races, such as sweet and dent corn. As a rule, the most desirable relationship for cross-breeding is between unrelated plants of the same variety.

**121. Effects of inbreeding and of cross-breeding on yield.**

Experiments have shown that continued self-fertilization of the corn plant reduces the yield; and when self-fertilization is practiced for several successive generations, it may dwarf the stalk and finally result in some measure of sterility



*Courtesy U. S. Dept. of Agriculture*

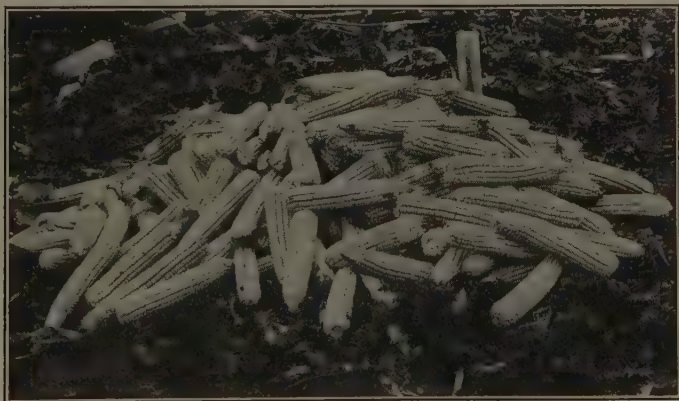
**Fig. 57. — Bad effects of continuous inbreeding**  
Compare with Fig. 58.

(Figs. 57, 58). Halsted (New Jersey Experiment Station *Bulletin* No. 170) found that self-pollination in sweet corn tended to increase the percentage of albino plants; that is, those with white foliage — an undesirable quality.

Cross-breeding, on the other hand, invigorates the strain, and some recent experiments show that it may greatly increase the yield in the first generation of cross-bred plants. It should be remembered, however, that cross-breeding of dissimilar types has the serious disadvantage of destroying

uniformity. It should be confined chiefly to plants of the same variety or to very closely related varieties.

**122. Inheritance of color.** Any part of the ear or grain that develops when pollen is excluded is obviously merely the outgrowth of tissue from the mother plant. By inclosing the young ear shoot in a paper bag, it is found that among the parts that develop in the absence of pollen are the cob and the hull (seed coats) of the grain. These parts



*Courtesy U. S. Dept. of Agriculture*

**Fig. 58.** — Larger yields and better ears are obtained from corn not inbred

Compare with Fig. 57.

(cob and seed coats) can not be changed in the current cross (that is, in the generation in which the cross is made) by pollen from a plant having a different character in these parts (84, 89).

Whenever grains of corn are red, the color is located in the hull. Proof of this is shown by the fact that meal from red corn is white after the bran has been carefully sifted out. Hence if the female parent has red grains, the grains maturing soon after a cross is made will be red, no matter

whether the pollen used is from a plant with yellow, with white, or with bluish grains.

In the same way if pollen from a red variety is placed on the silks of a white or yellow variety, the grains of the current cross will all be of the same color as that of the silk-bearing parent.

Very different is the way the yellow color of the corn grain is transmitted. The yellow color resides not in the hull but deeper in the structure of the grain; that is, in the endosperm. Proof of this is shown in the fact that meal from yellow corn is always yellow, even after the most complete removal of the bran.

Those parts of the kernel inclosed inside of the hull, that is, the germ and the endosperm (including the aleurone layer), may be visibly influenced by the pollen used in the current cross, that is, by double fertilization; these inner portions of the grain may display in a few weeks after the cross is made the color derived from the sire, or pollen-bearing plant. Now the yellow color is located in the endosperm. The purple color is located in the thin aleurone layer just under the seed coats. Both the endosperm and its aleurone layer are subject to double fertilization by pollen, and thus they are at once influenced in color by the male parent. Hence pollen from a pure yellow variety, falling on silks of a white kind, promptly makes the grains thus fertilized yellow. Likewise pollen from a lead-colored corn, falling on silks of a white variety, promptly makes the hybrid grains purple. This is because both the yellow and the lead colors, being in the endosperm, which may be influenced by the male parent (Fig. 32, *end.*), display their color through the transparent hull, or bran, inherited from the white mother plant. In the next generation these hybrid seeds produce grains of various colors or shades.

**123. Dominance of certain qualities in hybrids.** According to Mendel's law, certain pairs of opposite qualities are not inherited in mixtures or blends but separately, every individual descendant showing one or the other of these opposing qualities. The quality that shows in the greater number of the descendants is called *dominant*, while the quality showing forth in the smaller number of descendants of the cross is called *recessive*.

Experiments have shown, according to East (Connecticut State Agriculture Experiment Station *Report*, 1907-1908, Part VII, p. 41), that in corn the following characters are dominant over their opposites:

Yellow is dominant over white color of kernels.

Red is dominant over white color of kernels.

Purple is dominant over white color of kernels.

Flint quality of grains is dominant over dent.

Flint quality of grains is dominant over sweet.

Dent quality of grains is dominant over sweet.

Certain dominant qualities show in the current cross; among these are yellow or purple color of grains (when crossed on white varieties) and flintiness of grains, whether crossed on dent or on sweet corn. As a rule, the recessive grains, or those showing no effect of the cross in the second hybrid generation, are practically pure as to that quality, and these pure white or pure dent grains of the second hybrid generation subsequently come "true to seed." The grains showing the dominant quality, yellow color or flint structure, can not thus be selected as pure, because many of them have been influenced, though imperceptibly, by the recessive character (white color or dent structure). In other words, of the seed showing dominant qualities some are pure dominants and some are mixed though having the same appearance as the pure dominants.

**124. Practical results.** Practical application may be made of the somewhat technical statements in the last few paragraphs in the following way and in other operations in plant breeding:

(1) After the pollen of a pure yellow variety has been crossed on silks of a pure white variety, practically all of the grains of the current cross may be expected to be yellow or yellowish; all the pure white grains found in the second generation among the descendants of this cross may be considered as pure-bred so far as concerns color, and these white grains may be expected in all future years to produce only white grains.

(2) After the pollen of a pure white variety has been crossed on silks of a pure red variety, all the grains of that current cross will be red (because the hull of the grain is furnished by the mother parent, uninfluenced by the pollen used in the current cross); when these red grains are subsequently planted, the crop will contain a large number of red grains, most of which will be impure, as shown by their descendants' bearing both red and white grains.

On the other hand, the white grains, found in the second generation in smaller number among the red grains, are pure; and when these white kernels are planted, their offspring will consist entirely of white kernels.

In short, it requires many years to "fix" or perpetuate uniformly a dominant quality; but the opposite recessive character may be regularly reproduced in a much shorter period of years.

**125. Relative value of top and bottom ears for planting.** When there is any considerable inequality in size between two ears growing on one plant, the upper ear is generally the larger.

Using plants of identical parentage, Hartley<sup>1</sup> found that yield of grain per plant grown from lower ears was equally as great as the yield from plants grown from upper ears. He found the plants from middle ears (on three-eared plants) averaged 0.65 of a pound of ear corn to a plant, as compared with 0.70 of a pound from the offspring of both upper and lower ears borne by the same parent plants.

Redding (Georgia Experiment Station's *Bulletin* No. 55) obtained a slightly larger yield of grain from the offspring of bottom ears than from those of upper ears. The Alabama Experiment Station (*Bulletin* No. 134) obtained in 1903 with St. Charles White a greater yield from upper ears, but in 1905, in a more extensive test with the Experiment Station variety, there was practically no difference in the grain yield of plants tracing to upper and to lower ears. At the Rhode Island Station (*Bulletin* No. 116) Card found in sweet corn a tendency for the seed from upper ears to produce a greater number of ears per plant than seed from lower ears. This he assumed to be due to the more complete maturity and greater size of the upper ears of sweet corn.

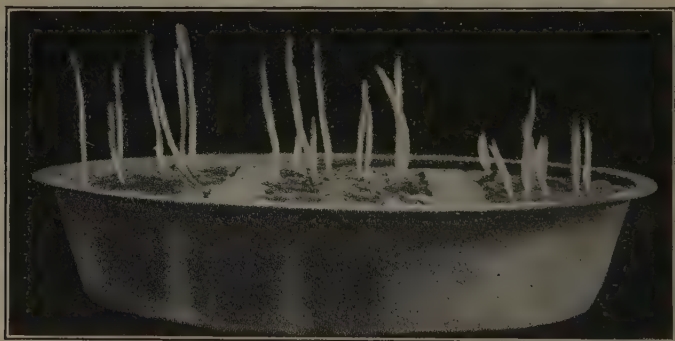
On the whole, available evidence is not sufficient to show any material difference between top and bottom ears for planting; and on theoretical grounds one should expect top and bottom ears, if equally developed in size and maturity, to be equally valuable for planting.

**126. Seed from different parts of the ear.** It is customary in the South to remove the grain for about an inch both at the tip and at the butt of the ear. Numerous experiments show little or no difference in yield of corn produced by planting grain from the tip, butt, and middle portion of the ear. Even when the experiment extended through

<sup>1</sup> American Breeders' Association, Vol. II, p. 124.

a number of successive generations, there were no notable differences in the yields.

Hartley found that the small kernels, usually on the tip, gave a higher percentage of weak and unproductive plants than larger kernels. Jeffrey (Michigan Experiment Station *Circular* No. 3) discovered that in most, but not in all varieties, the butt kernels germinated more slowly and the



*Courtesy Michigan Experiment Station*

Fig. 59. — Young corn plants

On left, from tip kernels; in middle, from middle grains; and on right, from butt kernels.

tip kernels more promptly than those from the middle of the ear (Fig. 59).

The Illinois Experiment Station has shown (*Bulletin* No. 55 and *Bulletin* No. 128, p. 460) that the tip kernels contain a slightly lower percentage of protein than the middle or the butt kernels, and that the butt kernels are slightly the richest in this constituent. The tip kernels contained a slightly larger proportion of starch than the others. Kernels from the tip, middle, and butt were practically alike in percentage of oil and ash.

On the whole, it seems advisable to remove the tip grains of the seed ears: (1) so as to secure seed of more uniform

size, an important consideration where a constant number of grains must be dropped by the planter in each hill; and (2) so as to avoid injured and very small grains, which would either fail to germinate or else cause the young plants produced from them to grow off slowly.

**127. Effects of change of climate.** Corn brought to the South from a cooler climate acquires year by year in its new home greater height of stalk and later maturity. With many highly improved varieties the grains apparently become shorter and the number of rows may be reduced.

As a rule, varieties from the Corn Belt are not adapted to those parts of the Cotton Belt having well distributed summer rain. They mature too early and make a smaller yield of grain and stover than native varieties, and the grain is often unmarketable, being weevil-eaten and chaffy.

Among the relatively few varieties from the Corn Belt which have in a few experiments shown fair yields of grain are Boone County White and St. Charles White. Even these afford a better grade of grain when the date of planting is rather late.

It is stated that for some parts of Texas early varieties are satisfactory on account of maturing before experiencing the full effects of summer drought.

In the region just north of the Cotton Belt, the Western varieties are more nearly on an equality with the native kinds.

As a general rule, the best seed corn is that produced in nearly the same latitude where it is to be grown. Usually corn of Southern varieties produced south of the Ohio and the Potomac River succeeds anywhere in the Cotton Belt. Corn growers just north of the Cotton Belt are able to use seed from a still higher latitude, but here too native improved varieties and locally grown seed are usually more satisfactory than seed corn from a widely different climate.

**LABORATORY EXERCISES****Comparison of ears.**

(1) Select five or ten plants with ears high above the ground and record the average height above ground of the node bearing the upper ear.

(2) Make the same record for five or ten plants in the same field with ears low on the stalk.

(3) If practicable, compare the maturity and weights of the shucked ears on the two types of plants just mentioned.

**Upper and lower ears.**

(4) Select ten plants, each bearing two well-developed ears. Shuck and compare the weights of (a) the ten upper ears and (b) the ten lower ears.

Does the upper or the lower ear develop and mature first?

(5) **TIP, BUTT, AND MIDDLE GRAINS.** Make germination tests of 100 tip grains, 100 butt grains, and 100 from the middle of the ear.

(6) **VARIATION.** Record for two plants of the same variety as many points of difference as you can discover.

What does this suggest as to the advantages of seed selecting and breeding?

**Color of grains.**

(7) Soak kernels of red and yellow corn, separate the coats, and determine in what part of the grain each color is located.

**Barren plants.**

(8) Determine in any field the percentage of barren stalks.

**Silks.**

(9) (a) With a magnifying glass examine the fresh silk sticking out beyond the shuck for hairlike branches and for pollen grains that have lodged on the silk.

(b) Tie large strong paper bags over several young ear shoots before any silks appear.

(c) A few days after the silks appear under the bags, note how much longer they are than silks which have received pollen.

(d) While the silks under one bag are still short and before any pollen has reached them, cut all the silks on one side of the ear, just inside the shuck; apply corn pollen on the remaining silks. In three weeks note the number of grains of corn developed on each side of the injured ear.

## ADVANCED TOPICS

A. A more detailed library study of the inheritable characters of the corn plant, both dominant and recessive.

B. Field and laboratory measurements to ascertain what qualities are correlated with each other or with yield of shelled corn per plant (*e.g.* number of ears on a plant, length of ear, height of plant to upper ear, etc.).

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## CHAPTER VIII

### CORN — SOILS, ROTATIONS, FERTILIZERS, AND TILLAGE

While corn will grow on an extremely wide range of soils, yet good yields can be expected only on rich or highly manured land. The corn plant, with its abundant foliage, actively engaged in transpiring moisture, needs large supplies of water. Therefore, the best soil for corn is one which can furnish a large and regular supply of water during periods of dry weather. Such a soil is usually a deep, rather rich loam, well supplied with vegetable matter. As a rule, bottom lands afford larger yields of corn than uplands.

**128. The soils most suitable for maize.** Bottom lands on which corn makes its best yields should be well drained since the corn roots need a constant supply of oxygen from the air and air can not penetrate saturated soil. Neither can the roots range to sufficient depth when the line of saturation is near the surface. The more poorly the land is drained, the later must the corn be planted and the greater the risk of failure, should the subsequent season be unfavorable. Uplands can be fitted for a maximum development of corn by gradually increasing the depth of plowing and by a constant addition of vegetable matter, by judicious rotation of crops, or by the application of barnyard manure.

In selecting land for corn, deep sand beds should be avoided, as being too poor and dry. The stiffest clays are also not desirable since they are often too compact for sufficient penetration by the roots and for thorough prepara-

tion, cultivation, and drainage. Corn is a favorite crop on new ground, or land from which the timber has just been cleared. It makes a fair yield even on soil that is slightly acid.

### ROTATIONS

**129. The place of corn in a rotation.** On cotton farms there is too frequently no effort to practice rotation or



*Courtesy International Harvester Co.*

**Fig. 60. — Increase in yield due to rotation and soil treatment**

Compare pile of corn on left (from rotation area) with pile on right showing corn grown continuously.

systematic change of crop from field to field. Especially is there a failure to alternate any other crop with corn for the reason that in the sandy and hilly country corn is generally planted on the narrow bottoms, which constitute the best corn land of these regions. In these cases (on the richer

bottoms), so long as the yield is satisfactory and no undue amount of disease appears, it is probably better to violate the usual rules of rotation and to grow corn continuously than to change to the shallow dry soils of the hills. However, tracts that must for this reason be cropped annually with corn should be supplied carefully with vegetable matter by one of the following methods: (1) Either one should grow cowpeas or other legume in summer among the corn plants, or (2) one should grow in winter a crop of crimson clover, bur clover, hairy vetch, or other winter legume to be plowed under in April or May as fertilizer for the crop of the same year.

**130. Three- and four-year rotations.** In the rotations best suited to the average cotton plantation, corn usually follows cotton and is succeeded by fall-sown oats or by wheat. This is because corn may be removed in time for the fall sowing of the small grains. Corn grown after cotton gets the advantage of the clean and late cultivation given to the latter, and hence corn can thus be produced with less labor.

A good three-year rotation is the following:

First year: cotton.

Second year: corn, with cowpeas or velvet beans between the rows.

Third year: oats or wheat, followed by cowpeas or soy beans.

This places corn on one third of the cultivated area each year.

The above scheme may be changed readily into a four-year rotation by growing two successive crops of cotton, the first of which may well be followed by a catch crop of crimson clover, plowed under by April 1 as fertilizer. This places corn on one fourth of the cultivated land.

However on some kinds of bottom land most varieties of velvet beans and cowpeas grow so luxuriantly as to pull down the corn plants and cause the ears to rot. The means



Fig. 61. — Cowpeas and corn

of avoiding this is to grow bunch varieties of velvet beans and cowpeas with the corn, or occasionally to grow there alone a crop of some winter or summer legume, such as vetch in the winter or soy beans in the summer season.

## FERTILIZERS

**131. Kind of fertilizers needed.** The soils that are richest in nitrogen usually produce the largest yields of corn. In experiments made on a wide variety of poor soils in Alabama, nitrogenous fertilizers have increased the crop to



*Courtesy Indiana Experiment Station*

**Fig. 62. — Effect of a complete fertilizer on corn yield**

Lime alone produced 30.3 bushels of corn per acre (right). When 300 pounds of complete fertilizers were added, the yield rose to 72.3 bushels per acre.

a much greater extent than any other kinds. Acid phosphate was generally next in importance but phosphates and potash were usually of far less value than when applied to cotton. However, the results of fertilizer experiments vary greatly according to the nature and previous history of the soil. No one fertilizer formula is best for all conditions. Usually 100 pounds of nitrate of soda per acre or corresponding amounts of other nitrogenous fertilizers may be

used with profit. In addition it will usually be well to apply 100 to 200 pounds of acid phosphate, not alone for the benefit of the corn but to fertilize the leguminous crop grown with it. Any potash required by the soil may well be reserved for application to cotton.

As a general rule, nitrogen is obtained at least expense by growing velvet beans, cowpeas, or other leguminous crops, either plowed under as fertilizer or thus used after having been consumed by animals. The accompanying large mass of vegetable matter also makes the land more retentive of moisture in periods of drought.

**132. Methods of applying fertilizers.** Experience shows that corn does not pay so big a profit as does cotton on a large quantity of commercial fertilizer. The risk is greater with corn because its critical period, from silking to the hardening of the kernels, is shorter than the fruiting season of cotton; drought at this time is likely to ruin the crop.

When nitrate of soda is the source of nitrogen, it should be applied wholly or in part after the plants have begun growth and long before they are ready for tasseling. It has proved most effective, as a rule, if applied when the plants are between one and four feet high. Nitrate of soda requires no covering if applied on damp soil. However, it is generally best for it to be covered slightly by the next cultivating furrow.

When less quickly available commercial fertilizers are applied to corn, they are usually drilled in either at planting or when the young plants are only one or two feet high.

Where ordinary amounts of commercial fertilizer, say 200 to 400 pounds per acre, have been employed, there has usually been little difference in yield whether the fertilizer was applied wholly before planting or a part during the early cultivation of the crop.

In the Williamson method of corn culture fertilizer is used in large amounts. It is all applied late as part of a plan for stunting the plants. The best features of this method are the use of liberal amounts of nitrate of soda, the thick sowing of cowpeas in the middles, and the thick planting of



*Courtesy International Harvester Co.*

**Fig. 63. — Manure and sometimes lime increase corn yields**

Where manure only was used, the production was 35.6 bushels per acre (left); with lime added 49.3 bushels per acre were produced.

corn, the latter being made possible by the moderate stunting of the corn plants.

### TILLAGE

**133. Time of plowing.** The time of preparation varies with conditions. The stiffer the soil and the larger the amount of vegetation to be plowed under, the earlier should plowing be done. On stiff soil plowing may well begin in

November. In spring the surface crust may be lightened easily by the use of a disk harrow just before planting.

There is considerable leaching, or waste of fertility, from plowed land left bare during the winter, especially the sandy soils. This loss is greater the earlier in the fall the plowing is done. Hence the preparation of sandy soil may be postponed until the stiffer lands have been plowed.

**134. Ridging *versus* level plowing.** Corn is planted (1) on beds, or ridges; (2) on land plowed flush, or level; or (3) in the water furrows between beds. Ridging, or bedding, is confined to a few regions in which the drainage is deficient (*e.g.* the stiff lime lands of parts of Alabama and Mississippi). The disadvantages of planting on high beds are: (1) a larger amount of surface exposed to evaporation and (2) insufficient depth of loose soil in the water furrow to support roots. Even where ridging is customary for corn planted early, it is not necessary when the date of planting is late.

**135. Level preparation and planting.** There are numerous advantages in plowing the land level rather than into ridges. As a rule, the soil is thus more completely turned and a greater variety of improved implements can be used — the disk plow, the row marker, and the checkrower, or two-horse corn planter. Moreover, except on very wet soils, the yield of corn is usually greater from level planting than from ridging.

**136. Planting in the water furrow.** On sandy upland soils in most parts of the Gulf states, it is the custom of many farmers to plant corn in the water furrow formed by first bedding the land, thus placing the seed in a deep depression. It is asserted for this method that by placing the plants deeper it brings their roots into a moist layer of soil and increases resistance to drought. It also makes tillage easier, saving part of the work with the hoe, for the reason

that the filling of the furrow by the cultivating implement readily covers and smothers young grass. Planting corn in water furrows is not advisable for stiff soils in humid regions. However, in some parts of the semiarid West corn is sometimes planted in deep furrows by a method known as *listing*;



*Courtesy International Harvester Co.*

Fig. 64. — Disc harrowing makes a good seed bed

one purpose of this method is to get the roots nearer the moisture supply, and another is to minimize the injury from the blowing of the soil.

**137. Preparation for planting in the water furrow.** This system is the most popular one on sandy uplands and other dry soils. When the preparation is to be thorough, ridges are made by back-furrowing in such a way as to leave the water furrows about five feet apart. The bed is not quite

completed, but a narrow strip, or balk, six to eight inches wide, where the water furrow will be, is left unplowed until the farmer is nearly ready to plant corn. Then with a shovel plow he throws out this balk and plants the seed in



*Courtesy International Harvester Co.*

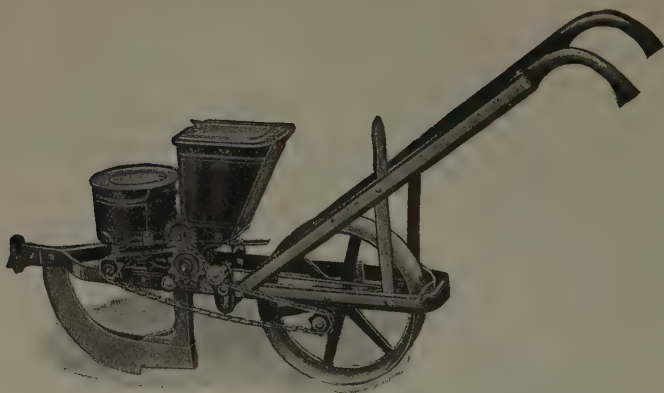
Fig. 65. — A two-row corn planter with a fertilizer attachment

Note on the extreme left the reversible "marker" for spacing the rows uniformly.

the freshly broken furrow, often by means of a combined fertilizer distributor and planter, which places both fertilizer and seed at the bottom of the newly made water-furrow and five to eight inches below the level of the highest part of the ridge.

During tillage the soil of the ridge is worked toward the plants in the water furrow so that, when the crop is laid by, the field is practically level.

**138. Depth of plowing.** Naturally this should vary with the character of the soil and the depth of the previous plowing. In general, it may be said that most Southern cornfields are not plowed deeply enough. The increase in depth is best made gradually, plowing each year one inch



*Courtesy International Harvester Co.*

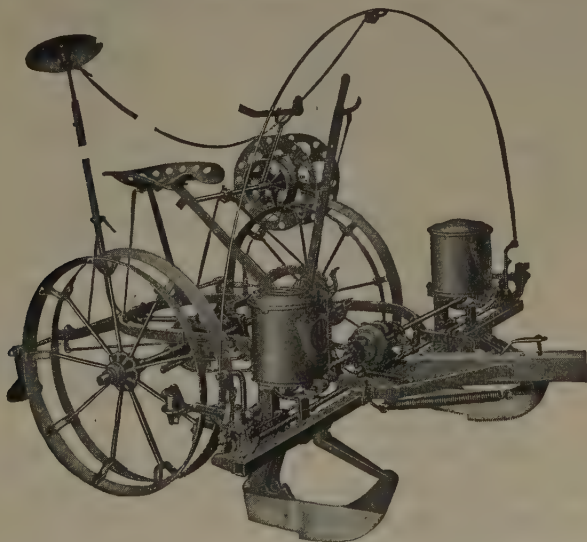
**Fig. 66.** — One-row corn drill equipped with shoe furrow opener and covering wheel

deeper than the preceding, until the desired depth is attained. Fall or early-winter plowing may be deeper than that done in February or March.

**139. Subsoiling.** In this process a special subsoil plow which loosens and slightly lifts the soil without inverting it is used. Subsoiling is best done in November or December before the subsoil becomes saturated by winter rains. Most experiments in subsoiling land subsequent to January 1 have shown no immediate increase or at least not enough to pay for the extra cost. Subsoiling once in three or four

years is probably frequent enough even for those soils that benefit by the operation. It is usually more economical and effective to increase the depth of ordinary plowing with a disk plow or turnplow.

**140. Planting.** Much corn is still dropped by hand, and in this case it may be covered by various implements. Much is planted by one-horse, or single-row, planters (Fig. 66), with which fertilizer distributors are often combined. The use of checkrowers (two-row planters) is restricted



*Courtesy International Harvester Co.*

**Fig. 67. — Checkrow corn planter equipped with runner openers**

in the South to a limited number of localities where the land is comparatively level. Planters save labor, usually afford a more even and prompt germination, and leave the young plants in straighter lines, thus making tillage easier.

**141. Depth of planting.** Corn may come up well when planted at almost any depth between one and four inches.

The general rule is to plant it just deep enough to insure a continuous supply of moisture. Hence, planting late in the season on a dry loose seed bed may require the seed to be covered with three or even four inches of soil. In the earlier part of the season one and one-half to three inches may be considered the best depth for most conditions.

The depth of rooting is not strictly governed by the depth of planting, since the few roots thrown out near the



Fig. 68. — Diagram of young corn plants

Showing that the depth of the crown, where most roots originate, is nearly the same with shallow, medium, and deep planting.

sprouting kernel are not the ones from which the plant draws most of its water and food (Fig. 68). Most of the permanent roots originate at the crown, which is usually about one inch below the surface of the soil, regardless of the depth of planting.

**142. Date of planting.** In the southern part of the Gulf states east of Texas, corn planting becomes general about the first of March; and in the central part of the Gulf states it is in full progress about the middle of March. In the northern part of the same states most of the planting is done in April. The corn planting season in all states

of the Cotton Belt practically extends from about the first of March to nearly the first of July. Bottom lands are frequently not planted until May or later, while in the same locality the preferred date for planting the uplands may be some time in March. Plantings made in June, even on bottom lands, are usually less productive than those made in May or earlier. A part of the corn is sometimes planted late in order to distribute the labor of cultivation through a longer period.

Only the seasons can determine whether in any given year it is better to plant uplands very early or at a medium date. The general belief inclines to the advantage of the very early planting of uplands, at least as soon as danger of a killing frost is past. However, success is sometimes made by planting at almost any date between the last killing frost and the first of June.

Incidental considerations sometimes govern the date of planting. For example, on land that is especially liable to the injury of young corn plants by the small bud worm (162), it is regarded as advantageous either to plant very early or, still better, to postpone planting until about the first of May. The common idea in postponing planting is that the soil becomes so warm as to discourage the insects. Probably a truer explanation is found (1) in avoiding the particular period when the insects are most active in egg laying and (2) in the more rapid growth of the late-planted corn, which sooner grows beyond the stage in which it is attacked by the bud worm.

Early planting has a tendency to produce a smaller stalk than late planting, which is a desirable result. Corn planted early requires a greater number of cultivations.

Late planting, while making a very tall stalk, reduces the injury from weevil by reason of the late date of maturity.

Late-planted corn, if harvested before becoming thoroughly dry, requires more ventilation of the cribs than is generally necessary with early-planted corn.

**143. Replanting.** Most farmers replant by dropping the seed by hand and covering with a hoe. This involves many

unnecessary motions and much waste of time. An improvement consists in the use of the rotary or other hand planter (Fig. 69), which, when thrust into the soil, leaves several grains covered at the proper depth.

**144. Harrowing.** A large part of the tillage should be given to corn land before the seed is planted; this is done readily by the use of some form of harrow (Figs. 64, 70). The best time to harrow is within a few hours after the plowing while there is still enough moisture in the clods to cause them to pulverize readily. Again, the harrow should be used either just before planting corn or just afterwards, and the operation may be repeated until the corn plants are four to six inches high. A weeder,

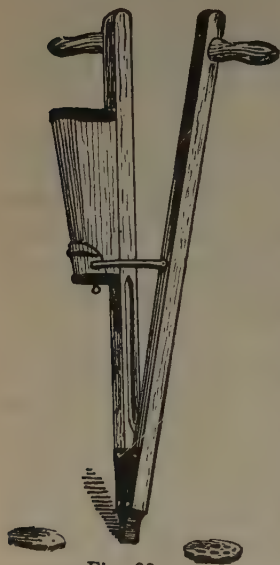


Fig. 69. —  
Hand planter for  
replanting corn

which is a light form of spring-tooth cultivator, may be used until the plants are eight to twelve inches high. It is usually best to run the harrow or weeder diagonally across the rows.

**145. Usual tilling implements.** Among the implements most generally used for cultivating corn in the South are heel scrapes, sweeps, and cultivators drawn by one or by two horses (Fig. 70).

The general rule should be to till corn shallowly, that is, to a depth of one and one-half to two and one-half inches, unless there are special reasons for deeper tillage. Sometimes comparatively deep tillage may be justifiable while the corn is less than one foot high, especially on land that



*Courtesy International Harvester Co.*

**Fig. 70.** — Spring-tooth cultivator with lever and lead wheel

contains much clay and that has been baked or run together by heavy rains or that was plowed imperfectly in the beginning.

When scrapes or similar implements are used, it is customary for the first working to be made with scrapes of the smaller sizes, usually ten to twelve inches in width, gradually increasing the size up to thirty inches or wider.

The first tilling of corn can be done much more rapidly if the cultivating implement is supplied with fenders which are usually strips of metal attached to the plow beam and trailing along the ground to protect the young plant from being covered by soil.

It is usually cheaper to kill young grass along the line of the drill by smothering it with earth thrown on it than by the use of the hoe; yet this working of the soil towards the plants should not be carried to such an extent as to form high ridges along the line of the row.

As a general rule, tillage implements with small points answer well for the destruction of very young grass and weeds and for forming a surface mulch. If crab grass or other tough vegetation attains considerable size, it is usually necessary to destroy it with some form of cutting implement, such as a scrape or sweep.

**146. Planting corn in checks.** Checking consists in planting corn in hills in such a way that it can be cultivated in two directions. This saves hoeing. Checking is advisable only on level or gently rolling lands. The yield of checked corn has usually been nearly the same as that from drilling where the number of plants per acre was about equal.

Corn may be checked either by using a checkrow planter or by carefully marking off rows at uniform distances and opening the planting furrows at regular intervals and perpendicular to the first marking. The seed corn may be dropped carefully by hand in the furrows where they are intersected by the cross mark. In using a checkrow corn planter, two rows are planted at once at uniform distances. A man riding on the machine regulates the distance for dropping the seed, or a wire attached to the planter and stretching across the field is equipped with enlargements

at measured intervals which serve to open the dropper automatically at corresponding distances.

**147. Thinning corn.** Since an excessive number of grains is planted, subsequent thinning becomes necessary. This should usually be postponed until after the plants are ten to twelve inches high, by which time the young plants will have ceased to die from injuries inflicted by bud worms. Thinning is done with a hoe, the young plants being cut below the ground or in wet weather being pulled from the soft ground.

**148. Number of plants to a hill.** Throughout the greater part of the Cotton Belt, except in its northern edge and occasionally on rich bottom lands elsewhere, it is customary to leave but a single corn plant in a hill, while in the North and West it is usual for from two to four plants to grow in one hill.

The Southern practice of leaving only one plant in a hill is due to the following conditions usually found in the South: (1) a thirsty soil; (2) comparatively shallow range of roots; (3) the large size of Southern corn plants and their consequent greater need for moisture; and (4) the fact that but little corn is planted in checks.

Under ordinary conditions and on land producing not more than 25 bushels of corn per acre it is doubtless best to leave only one stalk in a hill. However, where the land is capable of producing 35 or more bushels per acre and of being planted in checks, it will sometimes be advisable, in checking corn, to leave two plants in a hill.

**149. Distances between rows and plants.** The poorer the land, the farther apart must be the rows and the individual plants; while the richer the land, the more closely both rows and plants may be crowded together.

Experiments at the Georgia and Alabama Stations indi-

cate a slight advantage from so dividing the space allotted to each plant as to give practically the same distance between plants as between rows, the plants forming a square. However, economy of cultivation requires that this slight increase be sacrificed in order that the rows may be made as wide as practicable. Wide rows and closer planting in the drills save hoeing. For example, one laborer can hoe five acres of corn planted in 5-foot rows in the same time that he can hoe four acres if the rows are 4 feet wide. Horse cultivation is also economized by wider rows. Wide rows also permit the sowing and cultivation of a row of cowpeas halfway between each pair of corn rows.

**150. Laying by the corn crop.** "Laying by" is the name given to the last cultivation or tilling. Most farmers cease tilling corn just before the first tassels appear. Experiments indicate that a later tilling, if quite shallow, is often profitable. On the other hand, if the last cultivation must be deep or even moderately deep, it should not be late. Deep tillage doubtless explains the prejudice against late cultivation.

**151. Planting legumes with corn.** On most upland soils in the Cotton Belt, a summer legume should be planted in cornfields (129) (Fig. 61). In the southern parts of Alabama and Georgia corn and peanuts are often grown together. Peanuts may occupy every third row and are planted later than the corn. Sometimes velvet beans are also added to the mixture of corn and peanuts.

### LABORATORY EXERCISES

(1) Compare ten corn plants grown on a rich bottom soil with ten others of the same variety grown on a dry upland, recording: (a) average height of plant; (b) average height of upper ear above ground; (c) average number of square feet of ground occupied by each plant; and (d) average weight of shucked ear or ears per plant.

(2) Apply a teaspoonful of nitrate of soda to each corn plant on one row and each week afterwards compare the size and color of plants on this row with those that received no nitrate of soda.

(3) If corn plants are available for this purpose, study the effects of root pruning on four sets of plants, by running a knife or hatchet or axe three inches on each side of the row and to depths of 2, 3, 4, and 5 inches respectively. This may be repeated with plants of different heights between six inches and six feet.

(4) Most of the practice to accompany this chapter should consist of observations and note taking on such experiments as may be at hand or on methods in local use by farmers.

### ADVANCED TOPICS

A. A study of the results of fertilizer experiments with corn made by Experiment Stations having climatic conditions somewhat similar to those in your state.

B. A library study of the extent to which the stubble and entire growth of various legumes has increased the yield of the next year's crop of corn.

C. A library study of the results of tillage or cultivation experiments with corn.

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## CHAPTER IX

### CORN — HARVESTING AND ENEMIES

In the Southern States the usual methods of harvesting corn and corn forage are the following:

(1) Pulling or jerking the ears; afterwards stripping the blades.

(2) Pulling the ears; leaving the blades to be grazed by live stock.

(3) Pulling the ears; cutting the tops for forage.

(4) Cutting and shocking the stalks with ears and blades.

#### HARVESTING

**152. Harvesting and storing the ears.** A large part of the cost of producing corn is due to the excessive amount of handling of individual ears by the customary methods of harvesting corn in the Cotton Belt.

An improvement consists in throwing the corn directly into the wagon as it is pulled. This is more readily done if a "throw board," or sideboard, two to three feet high, is placed on top of the side of the wagon body farthest from the men. This necessitates loading the wagon from but one side.

The wagon should also have a hind gate that is readily removable so as to permit the use of a grain shovel in unloading. Elevating machines save much of the labor of unloading.

When it is advisable to husk the corn as it is pulled from the stalk, a husking pin buckled to the hand is helpful.

The shucking of the corn before storing it is useful in reducing the number of weevils introduced into the crib.

**153. Stripping blades and topping corn.** The custom of stripping the blades for fodder commonly reduces the yields of corn by several bushels for each acre. Where the leaves dry in place some of their substance is first transported to the ear, thus increasing the yield of grain. This advantage is lost when the green blades are pulled.

Topping removes but few leaves and so but slightly reduces the yield. The cost of labor in both operations is excessive and would be expended more economically in curing hay.

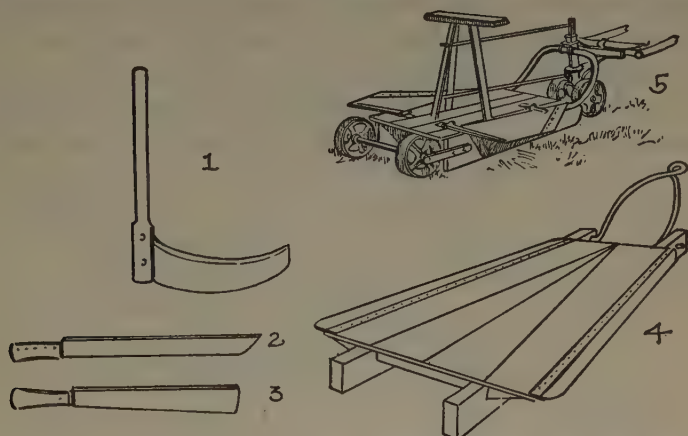
**154. Cutting and shocking corn.** When performed at the proper time, this does not materially reduce the yield of grain. The time to cut corn is when practically all outer shucks have turned a straw color, by which time the grains have hardened. This is usually about ten days later than the stage at which fodder is ordinarily pulled. The advantages of this method of harvesting corn are the following: (1) All the forage is saved; (2) the use of the land for the next crop, except a small space occupied by the shock, can be had at an earlier date; (3) it frees the land from corn-stalks and hence puts it in better condition for seeding to small grain; and (4) it permits the harvesting of the corn crop by machinery.

It would probably be a high estimate to say that thirty per cent of the total feeding value of the entire plant of large Southern corn is in the stover. Yet corn stover is a source of forage well worth saving, especially where hay is scarce or expensive.

There is usually about one ton of stover for every 25 or 30 bushels of grain produced by large Southern varieties. If this stover is shredded, it may have a higher feeding value than an equal weight of cottonseed hulls. In composition,

corn stover is superior to cottonseed hulls, but the former is less convenient for feeding in connection with cottonseed meal.

In one experiment in South Carolina, the cost of cutting and shocking corn was no greater than the cost of pulling



*From Morgan's Field Crops for the Cotton Belt*

**Fig. 71. — Corn-harvesting implements**

1, corn hook; 2, 3, corn knives; 4, homemade sled corn cutter; 5, sled cutter mounted on wheels.

the ears from an equal area of standing plants. However, the usual experience is that the former operation generally requires somewhat more labor than merely pulling the ears.

When no shredder is available, it is doubtful whether there is any advantage in cutting and shocking corn as compared with merely pulling the ears and grazing the field.

**155. Methods of cutting corn.** Corn may be cut (1) by hand implements, such as a hoe or corn knife, (2) by a sled cutter, or (3) by a corn binder or harvester. The choice between these is chiefly determined by the cost of each method and by the acreage to be cut. Even when the cost

of cutting by hand and by machinery is identical, the harvester has the advantage of making the owner less dependent on hired labor and of enabling him to do the work promptly and with less exertion.

**156. Cutting corn by hand.** The usual implement for cutting corn is a heavy corn, or cane, knife. Sometimes a sharp hoe is used. To form the shocks, either one may use a shocking horse (Fig. 72), or he may form a support for the shock by tying together the tops of plants on four hills, which plants are not cut. The row on which shocks are to



Fig. 72. — Shocking horse

*b* is a broom handle or gas pipe; the stalks are leaned in the four angles where the broom handle passes through the long board; after the shock is tied, the broom handle is pulled out and the shocking horse withdrawn.

be located is usually every tenth or twelfth row. As each armful of plants is cut, it is carefully placed on the shock in a nearly upright position. Some farmers prefer to cut first the rows adjoining the shock row, so that after placing the plants from these rows on the shock, a few minutes are allowed for these to dry slightly before the layers of plants from rows farther out are added to the shock.

In the South shocks should not be very large, but should usually contain between 150 and 200 plants. One that is too large is liable to fall and to result in the molding of

some of the immature ears in the center of the mass. A very small shock, on the other hand, exposes too large a proportion of its forage to injury from sun and rain.

The shock, when completed, should be tied tightly with binder twine, about two feet from the top. The shock can be drawn together by a short rope, in one end of which is a hook. The other end of the rope is passed through this hook and by means of a slip knot the shock is tightened while the string is being tied. About ten days later, after the plants have settled together, the tie should again be tightened in the same way. When shocks are being made, great care must be taken so to construct them that they will not fall later. Care should be taken in placing the plants against the shock, an equal number on all sides and in a nearly upright position, and in keeping the top of the shock from twisting, when pulled together by a rope.

The corn should stand in the shocks or in a rick at least one month before it will be dry enough to be shredded.

**157. The sled cutter.** This implement (Fig. 71) consists essentially of a sled on wheels; on one edge of this sled or low platform is attached a long sharp knife, sloping backward at an oblique angle to the row of corn. The sled is driven near enough to the row for the slanting knife to cut the corn with a sliding cut.

A man, standing on the platform, catches the cut corn in his arms; when he has an armful, he stops the team and places the corn on the nearest shock. The cost of a cutter made at home from a long scythe blade may be as low as \$10 (Fig. 71), while the cutters on wheels, with every facility for better work, cost fully twice as much.

The sled cutter is drawn by one animal or by two hitched tandem. If it is equipped with a blade on each side so as to cut two rows at once, two men catch and shock the cut

corn. For the convenient use of such two-row cutters, corn rows should be of a uniform width, suited to the width of the cutter.

**158. The corn binder, or harvester.** This machine cuts the corn and binds it into large bundles. It is usually drawn by a tractor or by mules. The cost is so high as to limit its



*Courtesy International Harvester Co.*

**Fig. 73. — A corn binder equipped with a bundle carrier**

use to those farmers or groups of coöperating farmers who can use it each year to cut a considerable acreage, say thirty acres or more. It cuts a single row at a time and may cut six or eight acres in a day. The cost of twine and of cutting and shocking is often about equal to the cost of cutting by hand and shocking, but the machine permits prompt work and economizes human labor.

The bundles from the machine must usually be stacked

by hand. Some binders have a bundle-carrying attachment, which reduces the labor of shocking. In any case, it is easier and more satisfactory to shock bundles than to shock unbound corn cut by hand.

**159. Shredding corn.** A shredder is a machine that tears the stover into small fragments and which, at the same time, removes the ear and takes from it nearly all of the shuck. To drive a shredder requires considerable power. Shredding



Fig. 74. — Double cribs arranged for loading and unloading from a central driveway

of shocked corn saves the hand labor of pulling and husking, insures only a small amount of waste in feeding, and affords finer manure than is obtained when the entire stalks are fed.

**160. Cribs and storage.** Slatted cribs insure ventilation and are especially useful for corn harvested while wet or immature (Fig. 74). A tight crib can be provided with ventilators capable of being closed when it becomes necessary to

destroy weevils by fumigation with carbon disulfid. The latter process is as follows:

For every hundred cubic feet of space in the crib, at least one pound of commercial liquid carbon disulfid, poured on old sacks or into shallow pans near the top of the pile, should be used. The corn should be covered with sheets or sacks

in order to confine the poisonous fumes.

It would probably also be advantageous, when practicable, to shuck the corn before storing it in such a tight crib for the following reasons: (1) The crib would hold about twice as many bushels of shucked as of unshucked corn: and (2) the weevils could be killed with a smaller amount of carbon disulfid.

Both tight and slatted cribs may be made rat-proof by lining them with



Fig. 75. — A field of corn that yielded more than 100 bushels per acre

coarse wire netting or by other means.

If a farmer puts part of his corn in a slatted crib and part in a tight crib, that from the slatted crib should be used first, since the corn in the tight crib can be kept sound

through the next summer by the occasional use of carbon disulfid, while the corn in the slatted crib may be severely attacked by weevils on the approach of warm weather or earlier.

Single loads of corn, whether shucked or unshucked, that can be left in the wagon for three hours or longer, for example



*Courtesy U. S. Dept. of Agriculture*

**Fig. 76. — Hogging down corn**

overnight, may be rendered weevil-free by the following plan, which is recommended by W. E. Hinds: Make the wagon body tight, preferably reinforcing it by folding a large grain sheet, or tarpaulin, over the bottom, sides, and top. Place about three pounds of carbon disulfid in shallow cans near the top of a large load of unshucked corn or a

smaller amount in each load of shucked corn. Such loads of fumigated corn should be placed in separate and detached cribs to be kept as the last corn used the next spring or summer. Keep lighted pipes and all lights away from carbon disulfid, since the fumes are highly inflammable.

**161. Yields of maize.** The average corn crop of most of the Southern States is below 20 bushels an acre, yet individual farms sometimes average more than 50 bushels. There are a number of authentic records of acre yields of more than 100 bushels of corn, made by Southern farmers on upland soil (Fig. 75).

The largest yield on record to 1923 was in the South. This was 254 bushels and 49 pounds of shelled corn (or "239 bushels of crib-cured corn") an acre, made by Z. J. Drake in South Carolina (Kansas Board of Agriculture, December, 1905, p. 208).



Fig. 77. — Bud worm of corn  
(enlarged)

On right, adult beetle; on left, base of a young corn plant showing holes made by bud worms; between, grub which bores into the young plant.

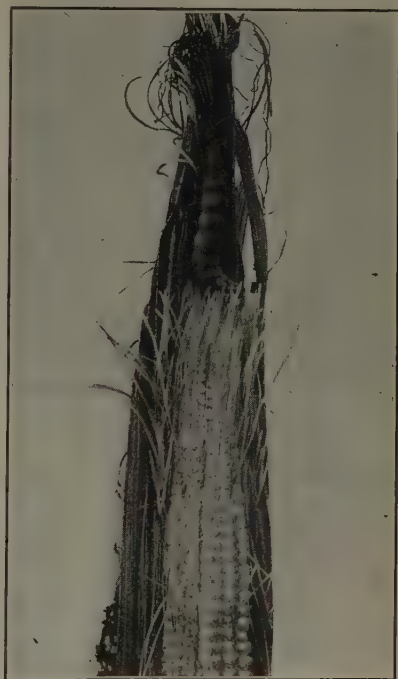
In this case the manure, cottonseed, and other fertilizers cost about as much as the value of the corn at the prices then prevailing. Most of the records above 200 bushels per acre have been made in the South by members of Corn Clubs.

## INSECT ENEMIES

**162. Bud worm.** This is the larval, or grub, stage of the twelve-spotted ladybird beetle (*Diabrotica twelve-punctata*). The mature insect feeds on almost any form of green vegetation. It is only about one fourth of an inch in

length; its color is a greenish yellow, and on its wing cases, or back, are twelve black spots (Fig. 77). The egg is laid on or near the young corn plant soon after germination, at a point just under the surface of the ground. The egg develops into a small white grub with a darker head, which bores into the central part of the young stem. As a result, the bud, or group of central leaves of the plant, wilts and usually dies. The injury is practically confined to the young plants between the heights of two and ten inches.

No direct remedies have thus far been found for the bud worm. The injury is worse in low wet land and in fields where weeds, corn, or certain other crops have grown. Rotation may be of some value, but the main reliance is in very late planting. Corn planted very early is also less likely to be seriously injured than when planting is done in mid-season. There seems



*Courtesy U. S. Dept. of Agriculture*

**Fig. 78.** — Corn-ear worm devouring corn silks

to be an advantage in causing the plant to pass as rapidly as possible through the earlier stages of growth, during which it is subject to this injury. To this end, small amounts of nitrate of soda, applied at the time of planting near each hill, are believed to be helpful. Fields where



From Watts' Vegetable Growing Projects

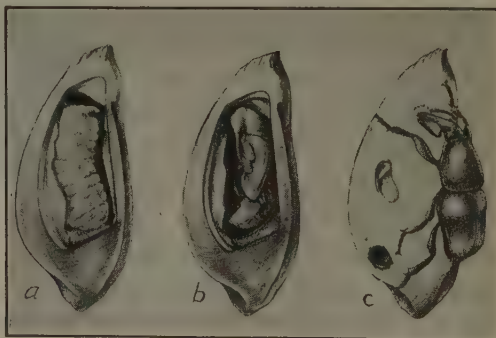
Fig. 79. — Injury by corn-ear worm

injury from bud worms is expected are usually planted quite thickly.

**163. Cutworms and grasshoppers.** Cutworms injure young corn plants, especially where clover or weeds grew the preceding year. They may be poisoned by scattering over the field just before the time of planting a mixture of one pound of Paris green or other arsenical with one bushel of wheat bran and one quart of molasses, the whole being thoroughly mixed and moistened with water. The same poison

mixture may be employed against grasshoppers when these become numerous.

**164. Corn-ear worm, or cotton bollworm (*Chloridea obsoleta*).** The eggs are laid by large grayish-brown moths on the silks, leaves, or other parts of the corn plant. After these hatch, the young worms, or larvæ, find their way



Courtesy U. S. Dept. of Agriculture

Fig. 80. — Three stages in the life of the black, or rice, weevil, that attacks grain (enlarged)

a, larva; b, pupa; c, adult.

into the tip of the ear, where they eat the developing grains (Fig. 78). They cause further damage by admitting weevils and the organisms that cause mold and smut. A preventive measure consists in plowing in late fall or winter to break up the underground burrows in which the chrysalis, or pupal stage, spends the winter. This insect sometimes seriously injures the bud or upper leaves of late corn just before tassels appear.

**165. Weevils (*Calandra oryza*) and grain moths.** The black, or rice, weevil (Fig. 80) attacks the matured corn grains in the fields and continues its depredations in the crib (Fig. 81).

Early varieties of corn and those with soft grains are most susceptible to injury. Late planting of medium or late varieties results in reducing the number of weevils finding access to the ears in the field.

The larvæ of several tiny grain moths also injure stored corn. The means of combating both weevils and grain moths in the crib consists in fumigation with carbon disulfid. The method is discussed in connection with cribs (160).

W. E. Hinds in Alabama has demonstrated that weevil injury may be prevented largely by the early planting of



Photo by W. E. Hinds

Fig. 81. — A corn ear showing damage by weevils

occasional trap rows of an early variety of corn. The ears maturing first on the trap plants attract the first weevils, which may be destroyed by the early harvesting and feeding of all ears from the trap rows.

### FUNGIOUS DISEASES

The corn plant is subject to a few diseases, the damage from which is not conspicuous and therefore probably underestimated. For most of the diseases of the foliage of corn satisfactory preventive measures have not been found. One means of minimizing root rot lies in judicious fertilization.

The diseases mentioned below cause much loss of grain.

**166. Corn smut (*Ustilago maydis*).** The presence of this disease is first shown by a large swelling on the ear, the stem, the tassel, or the leaf (Fig. 82). At first this protruding mass is covered with a whitish skin, which later bursts, setting free clouds of

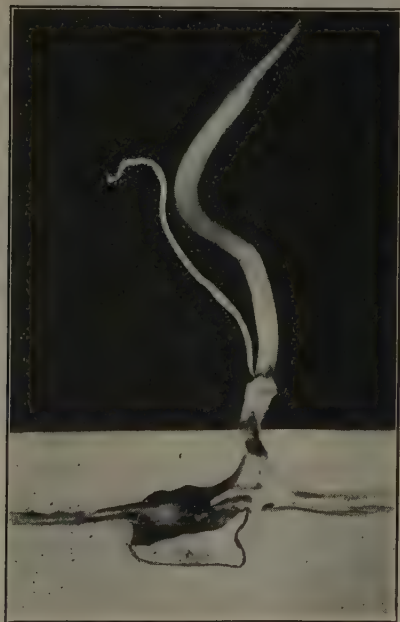


Fig. 82. — Corn smut

black powder. These powdery particles are the spores, or bodies answering the purpose of seed and serving to spread the disease to the next year's crop. These spores gain

entrance to the young plant after it has appeared above ground. The spread of this disease is due to smut masses left in the field by a preceding corn crop or blown in by the wind from surrounding cornfields. No treatment of the seed is effective.

The method of spread of the disease suggests the means of decreasing it in subsequent crops by the gathering



*Courtesy U. S. Dept. of Agriculture*

**Fig. 83. — Corn sprout from a diseased ear**

and burning of the smut masses before the whitish skin breaks and sets free the spores. Rotation of crops is advisable.

**167. Ear rots of corn.** These diseases have been found to be due to minute organisms, most of them belonging to

two groups of fungi (*Diplodia* and *Fusarium*), and in rarer cases to unidentified bacteria.



*Courtesy U. S. Dept. of Agriculture*

**Fig. 84. — Shredding ear shank**  
An indication of a diseased ear.

The Illinois Experiment Station (*Bulletin* No. 133) has found these fungous rots to be spread by spores left on the *shanks* of the corn plants of the two preceding years. Hence, the remedy is planting of corn on a field on or near which no corn, injured by these diseases, has been grown for the last two years.

Doubtless the burning of the diseased stalks promptly after harvest would tend to lessen the spread of ear rots to subsequent crops. Varieties differ somewhat in susceptibility. Hence breeding for increased resistance offers some promise of success as does the planting of sound kernels.

### LABORATORY EXERCISES

When practicable, students should spend several laboratory periods in the field comparing different methods of harvesting, for example:

(1) Determine the proportion of the weight of the shucked ear to the aggregate weight of shuck, leaves, and stalk, all thoroughly air-dried.

(2) Practice cutting and shocking corn; or if the crop is already in shocks, open and remake several of them.

(3) Examine the tips of a number of ears of corn and make an estimate of the percentage of ears injured in that field by the corn-ear worm.

(4) Examine corn in several cribs for weevils and record the apparent extent of damage, if any. Ascertain from the owner whether carbon disulfid was used and details of the treatment.

(5) Make germ nation tests, preferably in the open ground, of 100 weevil-eaten and of 100 sound kernels.

## ADVANCED TOPICS

A. A library study of the extent to which yield of grain has been affected by various methods of harvesting the forage.

B. A field practice to determine the amount of hand labor required in harvesting corn by different methods.

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## CHAPTER X

### RICE (*Oryza sativa*)

Rice is one of the grains included in the great family of the grasses. Its seeds are borne in loose heads, or panicles, at the top of each stem somewhat as in oats (Fig. 85). The root system is shallow and fibrous. Rice is grown along coasts, from the Carolinas south, and also in certain irrigable, low, inland regions. It is grown only in tropical and subtropical regions and in the southern part of the temperate zone. It is cultivated in practically all countries having such climates.

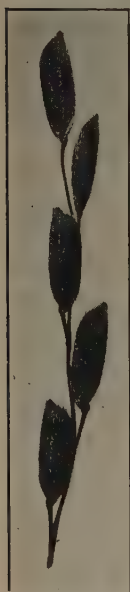


Fig. 85. —  
Seed branch of  
Honduras rice

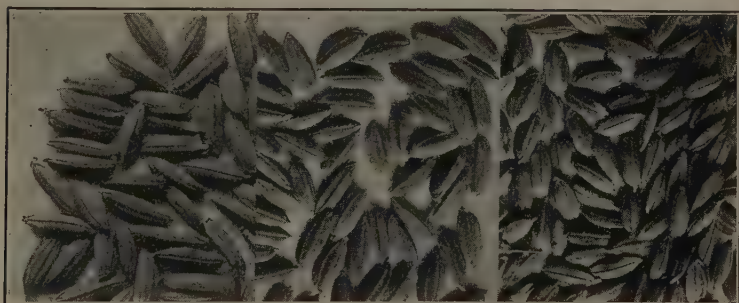
Rice serves as the principal food for a larger number of human beings than any other crop. In the densely populated countries of Asia, especially in China, India, and Japan, it is the principal article of food.

**168. Rice regions of the United States.** Until the Civil War rice production in the United States was centered in South Carolina and adjacent coastal regions. There the acreage is now very small because of cheaper production in other sections where labor-saving machinery can be employed more extensively. Rice culture next became important, chiefly soon after the Civil War, in the Mississippi bottoms in Louisiana. Not until the eighties did the rice industry become established in the southwestern part of Louisiana, the region which now pro-

duces about half of the American crop. Before 1910, rice production had become important in the prairie region of southeastern Arkansas. Since 1912 an extensive rice industry has developed in the Sacramento Valley in California.

The rice crop of the United States in 1922 was 41,405,000 bushels of which nearly one half was grown in Louisiana and close to one sixth in each of the states of California, Arkansas, and Texas.

The development of these new rice-growing regions has been chiefly due to their possession of abundance of irrigation water and to the presence of extensive areas of



*Courtesy U. S. Dept. of Agriculture*

**Fig. 86. — Rice grains (actual size)**

**Left, Honduras; middle, Blue Rose; right, Japanese Wataribune variety.**

level, stiff, nearly impervious soils, especially adapted to retain irrigation water.

**169. Uses.** The chief use of rice is as food for man, for which purpose it is prepared by special processes requiring completely equipped mills. In the milling process some of the most nutritious parts of the grain are removed but are utilized as feed for live stock. These by-products consist of rice meal and rice polish. Rice meal includes part of the highly nutritious embryo together with the thin seed

coat and adjacent outer layers of the grain. It is rich in fat as well as in carbohydrates. Rice polish is even richer in carbohydrates.

**170. Varieties.** While more than a thousand varieties (Fig. 86) of rice are recognized in Oriental countries, but few kinds are extensively grown in the United States. These consist of the long-grained rices, chief of which are the Honduras and Gold Seed varieties; kinds with grain of intermediate size represented in Louisiana by the Blue Rose variety; and the short-grained or Japan sorts. The latter make up the bulk of the California crop, where they are prized for their productiveness, hardiness, and small proportion of grain broken during the process of milling.

**171. Fertilizers.** Fertilizers are not extensively employed for rice. However, the soils of the prairie regions of southwestern Louisiana have been found to be deficient in phosphoric acid. Hence phosphates applied at such a time as to stimulate rice plants rather than weeds may sometimes be employed to advantage.

Rice, unlike other cultivated crops, is able to utilize nitrogen in the form of ammonia. When nitrogen is needed, it is recommended that it be supplied either by a preceding growth of legumes or by an application of sulfate of ammonia.

**172. Implements and sowing.** Only where preparation has been made for draining the land, can labor-saving implements be used in preparing for and sowing the crop and harvesting. Plowing is usually done in spring, but a preliminary plowing is often desirable in the early part of the preceding fall. The depth of plowing must be governed by local conditions. While deep plowing might otherwise be desirable, it risks inconvenience in harvesting, since in fields deeply plowed the wheels of the binder sink too

deep if much rain falls just before harvest time. The land must be further prepared by harrowing.

In the rice fields of South Carolina, which are very small and poorly drained, planting is done chiefly by hand labor. While broadcast sowing is not unusual, the method preferred in Louisiana consists in planting rice with a grain drill. This causes the seeds to be covered to a more uniform depth than is possible by broadcast sowing. Usually the grain drill should be preceded, and not followed, by the roller. The quantity of seed generally employed ranges from less than 90 pounds in Louisiana to a maximum of 150 pounds an acre in California. April is a favorite month for planting rice.

**173. Irrigation.** Since irrigation is necessary to large yields and to the most economical production, a retentive subsoil is required.

Water for irrigation is supplied in the Louisiana and Texas rice districts by pumping, the sources being either adjacent bayous and rivers or an underground supply. In the Arkansas rice-growing region water is secured from bored wells. In South Carolina irrigation is accomplished by admitting the water of the rivers when the fresh water is raised by the high tide, while the drainage of rice fields is accomplished at periods of low tide.

After a supply of water has been provided and brought to the highest part of the fields by a system of canals, low levees must be constructed so as to maintain the water at almost a uniform depth throughout a given section of the field. This usually should range between four and six inches on any one section of the field. Variations in the depth of irrigation water cause unevenness in the time of maturing and hence injury to the quality of the product.

After the seed are sown, it is sometimes necessary to

apply water for a day or two in order to cause the seed to germinate. In humid regions the seedlings may grow without water for about ten days after they emerge, or until they are about six to eight inches tall. At this time water is gradually applied until it reaches a depth of four to six inches. The field is kept submerged until about two weeks before the time of harvest. The presence of the disease "straighthead" may require the holding off of water for forty days or more after the plants emerge.

In California irrigation is required for germination. There good results have been obtained by seeding broadcast and then keeping the field continuously submerged or by seeding in water with subsequent continuous submersion. There too the uninterrupted covering of the surface with six to eight inches of water has been found to be the best method of preventing germination and growth of water grass, which is the most troublesome weed in the California rice fields. The method of irrigation practiced in South Carolina differs from that in the other rice-growing regions.

**174. Upland rice.** There are upland strains of rice that have become accustomed to being grown without irrigation and can not be distinguished from lowland rice. This so-called upland rice succeeds better when irrigated. For the culture of rice without irrigation, the best soils are drained ponds or moist bottom lands.

Since the crop must be kept free from grass and weeds by tillage, upland rice should be sown in drills, as close together as practicable without preventing the use of cultivating implements. The usual distance between rows is two and one half to three feet. Custom varies as to the thickness of planting in the drill. It is most convenient for the seeds to be dropped, a number in a place at distances of seven to twelve inches apart.

Several cultivations and one or two hoeings are usually given. The yields are much less than on irrigated land and the expense greater. The small rice hullers employed for milling small amounts of upland rice turn out a product highly nutritious but not sufficiently polished for the demands of commerce. Upland rice usually should be fertilized with acid phosphate and when necessary with potash and nitrogen.

**175. Harvesting.** The nature of the soil in Louisiana and Arkansas permits the drainage of the fields, so that the rice crop is there harvested by the use of self-binders.



Fig. 87. — Harvesting rice in Arkansas

After the grain has been somewhat further cured, it is carefully shocked and capped. "First, shock on dry ground; second, brace the bundles carefully against each other, so

as to resist wind or storms; third, let the shock be . . . capped carefully with bundles. . . . Slow curing in the shade produces the toughness of kernel necessary to withstand the milling processes. In the shock every head should be shaded and sheltered from storm as much as possible. The rice should be left in the shock until the straw is cured and the rice is hard." (S. A. Knapp, in *Farmers' Bulletin*, No. 110, United States Department of Agriculture.)

Threshing is done in the same way as with other grains (Fig. 87); usually in Louisiana directly from the shock. The crop is sold in the form of rough rice which yields about half its weight of marketable rice, besides rice meal, polish, and cracked rice.

**176. Weeds and other enemies.** The rice planter encounters his greatest difficulties through the invasion of the field by a multitude of troublesome weeds. The general methods of control are plowing at opportune times and flooding. The most troublesome weed in Louisiana is red rice.

Red rice is frequently accidentally sown with seed rice. It is a kind different from the types of rice cultivated in the United States and comes only from red rice seeds; it is capable of lying for several years buried deep in the soil, and then of germinating when turned up near the surface. A method recommended for ridding the land of this and of other weeds is to mow and thoroughly disk the field soon after harvest so as to cause the seeds of red rice and of other weeds to germinate. The young weeds are then killed by frost or, in some cases, mowed and burned.

Another method of fighting true weeds, other than red rice and other members of the grass family, consists in mowing the mass of young rice and weeds in the late spring or early summer, with the expectation that the rice will

then develop a central shoot while the true weeds will not make further growth.

Early spring plowing is sometimes practiced to induce the weed seeds to germinate; the young plants are then killed by cultivation before rice is sown.

Another method of getting rid of weeds consists in rotating rice with crops not requiring irrigation. Among leguminous crops especially suited to rotations for rice lands of the prairie regions is the soy bean.

**177. Insect and fungous diseases.** The insect that most severely injures rice plants is the larva, or grub, of a small gray beetle, the water weevil (*Lissorhoptrus simplex*). The grubs in summer feed on the roots of the rice plants. The remedy consists in temporary withdrawal of the irrigation water.

In the prairie regions of Louisiana *straighthead* sometimes causes considerable loss. This is a diseased condition not due to microorganisms. The seeds fail to fill, and hence the heads stand up straight instead of dropping. It occurs chiefly in the first crop of rice on land on which certain forms of vegetable matter have been plowed under. It is believed to be due to insufficient aëration of the soil for the normal decomposition of vegetable matter. The remedy recommended is withholding of irrigation water for forty days or more after the seedlings appear and then, after six weeks of submergence, withdrawing the water for a period of two or three weeks.

Rice blast, also called "rotten neck," may cause some heads to break off or fail to fill. Thus far no practicable treatment for this fungous disease has been found.

Rice is damaged by swarms of rice birds. The plants may be injured by salt water, which is found in some bayous in Louisiana when the water level becomes low.

## LABORATORY EXERCISES

(1) Examine a head, or panicle, of rice and make written notes showing (a) whether the head is compact or open and spreading; (b) whether the head remains erect or bends when ripe; and (c) whether the grains are borne singly or in groups.

(2) (a) Is the unhulled grain of the variety studied somewhat hairy? (b) Is there a beard (awn); and if so, is it a continuation of the central ridge or nerve of the lemma?

(3) (a) Is the endosperm of the rice seed grown to the hull, as in barley, or merely held tightly, as in oats? (b) What is the color of the unhulled grain? (c) What is the color of the grain after the removal of the hull?

(4) (a) Is the embryo sunken or projected above the adjacent part of the hulled grain? (b) Can a part of it be rubbed off readily? (c) In milling would the embryo (which is the part of the grain that is richest in fat) be retained for human food or would it be rubbed off as a part of the rice bran that is fed to live stock?

## ADVANCED TOPICS

A. Laboratory studies of structural peculiarities of the rice plant and grain, especially (1) number of temporary, or seed, roots on germinated grain; (2) size of ligule; (3) uniform texture of lemma and palea; (4) number of stamens; (5) varietal differences, including awns, hairiness and color of hull, dimensions of unhulled grains, etc.

B. A statistical study of rice production by periods and by states.

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PART II  
COTTON



## CHAPTER XI

### COTTON — STRUCTURE AND GENERAL CHARACTERISTICS

Cotton is the world's most important fiber plant. The cotton plant as generally grown in the United States is of erect or bushy form and usually three to seven feet tall. In this country it is an annual, being killed by frost in the fall. In its native home in the tropics the cotton plant is a perennial, living for many years. Suggestions of this perennial habit are afforded after a mild winter in the southern part of the Cotton Belt by the sprouting of plants from the old roots or stems.

**178. Stems and branches.** The cotton plant consists of an erect central stem, usually three to six feet long, from the nodes of which branches arise. Stems and branches are woody and solid. The length and arrangement of branches are important as means of distinguishing varieties and as indications of productiveness and earliness.

The longest limbs of cotton are usually near the base of the plant, the length decreasing towards the top of the main stem. This gives to cotton plants of most varieties a cone-shaped, pyramidal, or sugar-loaf form. However, in varieties known as "cluster cottons," there are a few long limbs near the base of the plant; all branches above these basal limbs are only a few inches long, thus giving a slender or "erect" appearance to the upper two thirds of the plant. Between cluster cotton and wide-spreading, long-limb kinds there are all gradations in length of branches.

Each branch arises from the main stem in the angle between a leaf and the main stem. Usually this leaf on the main stem falls before the branch attains much size, but its position is shown by the leaf scar.

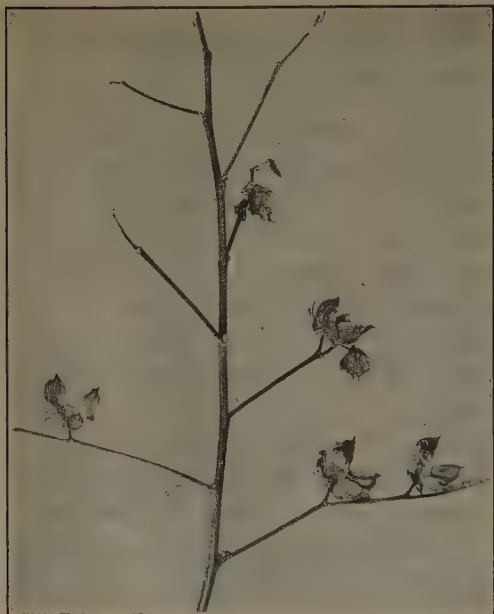


Fig. 88. — A part of a vegetative limb

Note that boll stems are attached to its branches which are fruit limbs.

The plant has two classes of branches, or limbs. The longer, ascending ones (Fig. 88) are sometimes called vegetative, or primary, branches, while slenderer or shorter branches to which bolls are attached *directly* by their flower stalks or boll stems (peduncles) are called fruiting limbs (Fig. 89). The primary branches have also been called sterile limbs; this is because no boll stem or boll is borne directly on

these vegetative limbs, though boll stems with attached bolls spring from the subdivisions of these main branches.

In general, a primary branch supports numerous leaves and, on its sub-branches, some bolls; while a fruiting limb usually bears several bolls and but few leaves.

Normally two branches arise from the axil of a leaf on the main stem. One of these twin branches, arising from

the same node of the main stem, is a fruiting branch and the other a vegetative, or so-called sterile, branch. At many of the nodes one or the other of these branches fails to develop conspicuously and is represented merely by a tiny shoot, or bud. If a vegetative limb develops at nearly every node, the plant presents a very bushy, round-topped, leafy appearance, and the bolls may be relatively few and too much shaded.

The yield and earliness is increased by selecting seed from plants on which a large proportion of the fruit limbs develop fully and on which there are relatively few fully developed vegetative branches.

On the main stem of some plants above the primary branches the fruit limb is invariably on the left side of the sterile limb, while on other plants the fruit limb is uniformly on the right side of its twin vegetative branch.

**179. Maturity or earliness.** Those cotton plants are earliest in maturity that are short-jointed and that put forth their lowest limbs from nodes near the ground. For earliness and productiveness there should be numerous



Fig. 89. — A fruiting limb

Note that the boll stems are attached directly to the fruiting limb.

nodes close together on the main stem. Likewise on the limbs the distance between bolls, or between secondary branches, should be short.

**180. Roots.** The cotton plant is supplied with a taproot, or continuation of the stem, from which the lateral roots



*Photo from Raymond*

**Fig. 90. — Picking cotton in Texas**

branch. In deep well-drained soil the taproot may go far into the ground, but on shallow soil or on that insufficiently drained the taproot often turns and grows in a horizontal direction on coming into contact with a dense or undrained subsoil.

Most of the lateral roots arise at points two to four inches below the surface of the ground. Hence, deep cultivation after the plant is several inches high results in the destruction of many of the lateral roots.

**181. Leaves.** The leaves of cotton are alternate in position on the stem or branch. They vary somewhat in size and shape, even on the same plant. In American varieties, both of the short-staple and long-staple upland classes, the leaves are usually three-lobed, sometimes five-lobed. In these classes the spaces between lobes are usually shallow. Certain groups of varieties, chiefly the big-boll kinds, have large leaves with quite shallow indentation and short broad lobes. Other groups, notably those of the King type (Fig. 101), have smaller leaves with slenderer, more sharply pointed lobes. In sea-island cotton the lobes are very slender and the indentations very deep (Fig. 91).

There are usually three (sometimes more) prominent veins or ribs in each leaf. On one or more of these on the under side of the leaf are glands that may be seen readily. The leaves of upland cotton are covered, especially on the lower side, with numerous short, inconspicuous hairs.



Fig. 91. — Cotton leaves  
a, upland; b, sea-island.

**182. Boll stems, or peduncles.** Connecting the flower or boll with the branch is a short flower stem (Figs. 88, 89), ranging in American upland and long-staple upland varieties from half an inch to about two inches in length.

**183. Flowers.** The three green parts, which together make the "square," are bracts, or flower leaves, and serve to protect the flower bud. The blooms are large and pretty, their size and color varying in different species.

In American upland and long-staple upland the bloom is of a pale-cream color on the morning that it opens. On the second day it changes to a pink or red and later falls. The flowers open early in the morning and close late in

the same day. In sea-island cotton, the young bloom has a more yellowish tint than the flower of upland cotton.

The pollen is heavy and waxy, and apparently it is carried almost entirely by insects. However, cotton is capable of self-fertilization, as shown by the fact that if a hundred flower buds are inclosed by paper bags, bolls containing seed will develop in most cases. It is probable that cross-fertilization tends to increased vigor. At least the seed from artificial hybrids between American upland varieties have been found to be larger than the average of the seeds of the parent varieties. (Alabama Experiment Station *Bulletin* No. 56.)

There are five conspicuous petals and five inconspicuous sepals, the latter united into a shallow cup around the base of the flower and boll. The pistil, or central part of the flower, is divided into from three to six divisions or stigmas. Three is the prevailing number of stigmas in sea-island cotton and four or five in American upland varieties. The number is the same as the number of locks of seed cotton that will develop in that particular boll. The stamens are numerous and are grouped closely around the pistil just below the stigmas. Their supporting parts are united to form a tube that encircles the lower portion of the pistil.

The pollen is released from the pollen cases (anthers) several hours after sunrise, or about the same time that the stigma is in condition to receive it.

Two varieties of cotton readily cross by the carrying of pollen by insects from one flower to another. Webber has estimated that only about 5 to 10 per cent of the seed from two varieties grown near together produce hybrid, or crossed, plants.

Glands, or minute organs secreting a sweetish substance, are found on both the flowers and leaves of cotton. In the

flowers of American cottons there are glands at the base of the bracts and also at the base of the petals. On the under side of the leaves the glands occur on one or more of the midribs, or veins. The glands are probably means of attracting insect visitors and thus of increasing the amount of crossing between varieties or between individual plants of cotton.

**184. Bolls.** The pod containing the seed and lint is called the boll (Fig. 92). In short-staple cotton there are



*Courtesy California Experiment Station*

**Fig. 92.** — Bolls of upland big-boll and Pima (American-Egyptian) varieties

usually four or five divisions of each boll; the content of each division is called a lock. While American upland cottons, both long- and short-staple, have usually four or five locks, a boll of sea-island cotton contains only three or four.

In tests made at the Alabama Experiment Station, bolls with five locks afforded a larger yield of seed cotton to the boll than did bolls having only four locks.

The number of bolls varies somewhat with different varieties but is chiefly dependent on conditions of fertility, rainfall, and climate. The number may vary between a few and several hundred on a single plant. A field averaging

fifty mature bolls to a plant usually makes considerably more than a bale of cotton (500 pounds of lint) to an acre. Cotton plants of medium size, three to five feet high, are likely to be more heavily fruited in proportion to size than very large plants. Short internodes, or spaces between branches, are favorable to productiveness. An ideal cotton plant should have a number of nearly horizontal fruiting



Fig. 93. — Open cotton boll showing burs

limbs, beginning near the ground, and continuing to arise at each node until considerably above the middle of the plant. Each fruiting limb on the lower part of productive plants should mature at least four bolls.

Cotton bolls of the sea-island varieties are usually less than one inch in diameter and of slender tapering shape. Bolls of American upland cotton vary greatly in size and

shape according to variety and the character of soil and season. The diameter usually varies between one and one-quarter and one and three-quarter inches, and in most cases the bolls are considerably longer than they are thick. Rich land and high fertilization together with abundance of moisture tend to increase the size of bolls (Figs. 92, 95, 96).

Bolls of upland cotton are usually of such size that from 60 to 110 are required to make a pound of seed cotton.

When the boll ripens, it splits usually into four or five divisions, exposing the seed cotton. The parts of the pod,

or bur, separate more or less completely. If they open wide and the outer walls of the burs curl backward, the seed cotton may be held so slightly that it is easily blown out by wind or beaten out by rain.

**185. Storm resistance.** The structure of boll most favorable to "storm resistance," or persistence of the seed cotton

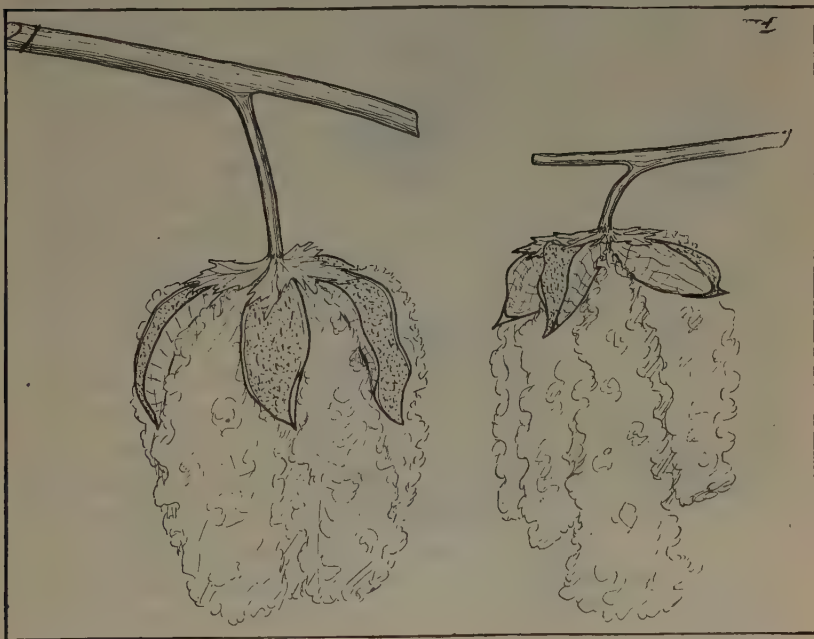
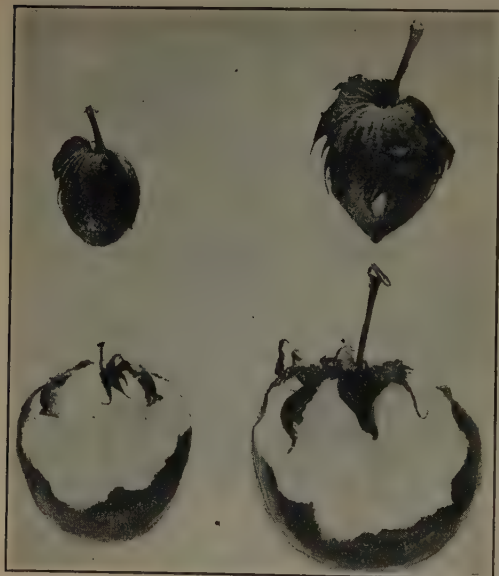


Fig. 94. — At left, an open boll of a "storm-proof" variety; at right, an open boll, showing locks falling from thin reflexed bur

in the bur, is the following: (1) a firm stiff wall, which on drying does not curl backward (Fig. 94); (2) only medium separation of the parts of the matured bur; (3) a partially drooped position of the boll; and (4) the presence of large bracts, or flower leaves.

**186. Lint.** Each cotton fiber consists of a single elongated cell. The fiber may be thought of as a tube, which, while immature, is cylindrical throughout more than three fourths of its length; thence it tapers to the end farthest from the seed. As the fiber matures, the tube collapses and becomes

twisted, somewhat like a collapsed and twisted fire hose. This twisting, which is most complete when the fiber is thoroughly matured, is highly desirable because it adds strength to the cotton thread or yarn by causing the fibers to cling together when spun. The advantage of the twisting in preventing the slipping of fibers in a thread or cloth may be understood by



*Courtesy N. C. Experiment Station*

**Fig. 95.** — Comparative sizes of bolls of two strains of upland cotton (reduced)

considering how much more difficult it would be for two chains twisted together to slip past each other than it would be for two pieces of smooth wire.

Based chiefly on the amount of twisting, there are in every lot of cotton three kinds of fibers: (1) ripe, (2) partly ripe, and (3) immature. In immature fibers there is little twist; consequently these make weak thread or cloth. Moreover, immature fibers do not uniformly and satisfac-

torily absorb the dyes used in the manufacture of colored cloth. Therefore, to secure the best grade and price, bolls of cotton should not be picked until well opened, thus giving an opportunity for sun and air to mature the fiber.

The value of cotton fiber is determined by (1) length, (2) strength, (3) maturity, (4) fineness, and (5) uniformity. The longest fiber is usually the finest, and such fibers may be used in the manufacture of the finest, thinnest, and most expensive cotton fabrics.

The following are approximately the average lengths of the fibers of the principal kinds of cotton:

Sea-island, 1.61 inches;

Egyptian, 1.41 inches;

American upland, 0.93 inch;

American long-staple, 1.3 inches.

The fiber is longest on the larger or upper end of the seed.

The average diameter of American upland short-staple cotton is  $\frac{1}{1500}$  to  $\frac{1}{1200}$  inch. The cotton fiber attains its maximum length before reaching its maximum diameter and strength.

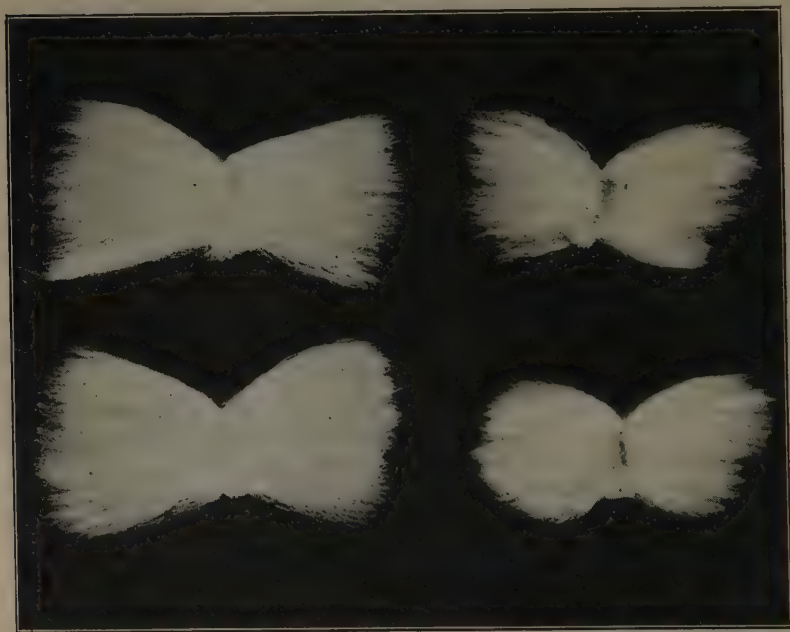
Williams (North Carolina Board of Agriculture *Bulletin*, September, 1906) found that in twelve varieties of cotton, the average weight required to break a single fiber was 6.83 grams. Hilgard found the extremes of breaking strength of cotton to be 4 and 14 grams. Cotton is about three times as strong as wool in proportion to the size of fiber. In a pound of Russell cotton there were calculated



Fig. 96. — Various shapes of bolls

On left, sea-island; in middle, typical long-staple; on right, typical short-staple of the big-boll group (all reduced).

to be more than 15,000,000 fibers, which, if placed end to end, would make a line about 2000 miles long. Cotton fiber is prevented from readily absorbing moisture by an oily covering of each fiber, which is said by Monie to make up about 2 per cent of the weight of the fiber. Absorbent cotton represents cotton from which this oily protection



*Courtesy N. C. Experiment Station*

Fig. 97. — Difference in length of lint in two upland cottons

has been removed by treatment with chemicals. The oily covering must be removed before the yarn can be dyed.

It is thought by farmers that, if seed cotton is stored for some time before ginning, the proportion of lint will increase and that it will then make a better-looking sample. If this is true, there is need for investigators to determine

whether there is an increase in the weight of this oily covering during storage.

**187. Seed.** There are usually six to twelve seeds in each lock of seed cotton, or from twenty-eight to fifty seeds in a boll. In varieties with small seed, the number to a boll is usually greater than in varieties having large seed.

The legal weight of a bushel of seed is usually either 32 or 33½ pounds. A bushel may be regarded as containing about 135,000 seeds of average size.

A bushel of sea-island cotton seed is usually assumed to weigh about 44 pounds. In the author's classification of upland cotton, seed averaging 13 grams to 100 seed are considered as large; those weighing 10 to 13 grams to 100 seed as medium; and those weighing less than 10 grams to 100 seed as small.

The seed of most varieties of upland cotton are covered with a short dense fuzz which may be white, greenish, or brownish. There are some exceptional varieties almost free from this fuzz or so thinly covered that the black seed coat shows through. Sea-island cotton has naked black seeds free from fuzz except on the tip end of some of them. Constant selection is necessary to prevent an increase in the fuzz on sea-island cottonseed.

Within the tough hull of the seed is the "meat," which consists chiefly of two fleshy seed leaves (cotyledons) enfolding the embryo sprout and the embryo root.

In the entire seed the following figures represent approximately the usual proportions of the different parts:

Linters, or short lint, removed at the oil mill . . . . .	10 per cent
Hulls . . . . .	40 per cent
Meats. . . . .	50 per cent

When planted in the field in the spring under favorable weather conditions, germination usually occurs in seven

to twelve days. Cotton seeds retain their power to germinate for several years. The seed leaves, or first two thick leaves that appear, serve to nourish the plant before the appearance of true leaves.

**188. Stages in the life of flower and fruit.** When the plant is about forty days old, the first squares, or flower buds, usually may be seen. If planting is done in hot weather, the squares mature more quickly. Mercier reports that twenty-one days is the time from the first appearance of the square to the opening of the bloom. From the open bloom to the open boll the time varies according to the season of year and the variety. As a rule, in very hot weather, forty-two days is sufficient; while in the cooler weather of the early fall, fifty or more days may be required. Therefore, blooms appearing fifty days before the average date of frost in a given locality may be expected, under normal weather conditions, to mature.

### LABORATORY EXERCISES

(1) Tie a string to the lowest branch of a well-grown cotton plant and wind it spirally around the plant, in such a way as to touch the base of each branch. By repeating this on several plants determine the number of the branch from the bottom that is directly above the lowest branch.

(2) Make a record of how many times the string passes entirely around the stem in being wound spirally from the lowest branch to the one directly over it.

(3) Compare as to earliness of maturing several plants with long internodes on the main stem and the branches with others of the same variety having short intervals between limbs or leaves.

(4) Weigh the mass of seed cotton from fifty bolls each having five locks and that from fifty four-lock bolls; record and compare the weights.

(5) Find five storm-resistant bolls or old burs and write down the apparent reasons for the storm resistance of each.

(6) Pull and break a small number of fibers of immature but dry lint and note how much less force is required to break these than to break fully matured cotton fibers.

## ADVANCED TOPICS

- A. An intensive field study of the cotton plant, including branches, leaves, flowers, and bolls.
- B. A microscopic examination of fibers.

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## CHAPTER XII

### COTTON — COMPOSITION AND PRINCIPAL USES

Of course, the great usefulness of cotton lies in the lint, or fiber. In fact, when one speaks of "cotton," one usually refers to the fiber rather than to the plant as a whole. There are other uses, however, that must be considered; and it is important to know the chemical composition of the parts.

#### COMPOSITION

**189. Lint.** Cotton lint consists mostly of woody fiber (cellulose), which is formed chiefly from the carbon dioxide of the air. A bale of cotton (500 pounds of lint) contains only 1.7 pounds of nitrogen, half a pound of phosphoric acid, and 2.3 pounds of potash. If these substances are rated at their prices in commercial fertilizers, the plant food removed in a bale of cotton would be worth only about 54 cents.

In selling only the lint the farmer removes from the soil a smaller amount of fertility than in growing any other American crop. When cotton lands decline in fertility, it is not because of the lint removed, but chiefly on account of the failure to rotate crops and thus to replenish the supply of vegetable matter.

**190. Seed.** The seed of cotton, unlike the lint, is rich in nitrogen, phosphoric acid, and potash. Hence the sale of cotton seed removes large quantities of these forms of plant food.

For example, 1000 pounds of seed, which is approximately the amount usually accompanying one 500-pound bale of lint, contains about 31 pounds of nitrogen, 13 pounds of phosphoric acid, and 12 pounds of potash. To replace this quantity of plant food would require commercial fertilizers costing about \$6 to \$10. The draft on the fertility of the land made by other parts of the plant are indicated in later paragraphs.

**191. Composition of cotton products.** The most valuable products of the cotton plant, next to the lint, are those made from the seed. In round numbers there are produced annually in the United States half as many million tons of seed as million bales of cotton. More than two-thirds of the seed is used by the oil mills and less than one-tenth for planting; the remainder is either fed directly as seed to live stock or else employed as fertilizer. The oil in the seed has no fertilizing value; hence more wealth is created when the oil mills use the seed than when the seeds are employed as fertilizer, provided the farmer buys enough cottonseed meal or other forms of commercial fertilizer to restore to his land the plant food removed in the seed. At prices prevailing in recent years, a dollar buys a larger amount of plant food in the form of cottonseed meal than if invested in cotton seed. Even more economical is usually the purchase of mineral or other fertilizers having no value as feed for live stock.

A ton of cotton seed ordinarily produces approximately the following products at the oil mills:

	POUNDS
Oil (38 to 45 gallons), average about . . . . .	300
Cottonseed meal, average about . . . . .	900
Cottonseed hulls, average about . . . . .	600
Linters, average about . . . . .	70
Waste, sand, trash, and evaporation, average about . . . . .	130
Total . . . . .	<u>2000</u>

The food and fertilizer constituents contained in one ton of cotton seed and of a similar amount of *high-grade* cotton-seed meal are as follows:

TABLE VIII. POUNDS OF FOOD AND FERTILIZER CONSTITUENTS IN ONE TON OF COTTON SEED AND OF HIGH-GRADE COTTONSEED MEAL

	COTTON SEED (Pounds)	COTTON- SEED MEAL (Pounds)	COTTON SEED RICHER BY (Per cent)	COTTON- SEED MEAL RICHER BY (Per cent)
Principal food constituents				
Protein . . . . .	397	846		113
Nitrogen-free extract . . . .	469	472		1
Fat . . . . .	398	204	95	
Fiber . . . . .	451	112	303	
Fertilizer constituents				
Nitrogen . . . . .	63	113		79
Phosphoric acid . . . . .	25	54		116
Potash . . . . .	23	36		57

**192. Utilizing cottonseed products.** From the above table it may be seen that, regarded as food, and slight differences in digestibility being disregarded, cottonseed meal is much more valuable than cotton seed, having more than twice as much protein, but less fat and fiber.

In fertilizer constituents high-grade cottonseed meal is practically twice as rich in nitrogen and phosphoric acid and more than 50 per cent richer in potash than cotton seed.

The farmer may act on the general statement that, disregarding the cost of hauling, he is making a nearly even exchange in plant food when he brings back to his farm a little more than half a ton of cottonseed meal for each ton of seed sold.

But in food constituents, cottonseed meal is not twice as rich as cotton seed. The exchange values of these two foods will depend on many conditions, especially the kind of roughage to be fed in connection with either, the purpose in view, and other matters that find a place in textbooks on feeding animals. In tests at the Mississippi Experiment Station, a pound of cottonseed meal was in one case equal as food to 1.6 pounds of cotton seed; and in another case, to 1.7 pounds.

In general, one may expect a ton of cotton seed to have the same feeding value as an amount of cottonseed meal varying between 1250 and 1500 pounds.

**193. Composition of the different parts of the plant.** The stems contain nearly one fourth of the dry matter, the leaves and seeds each a little more than one fifth, and the lint only one ninth of the total dry matter in the mature plant. The seed and lint, which are usually the only portions of the plant removed from the land, together constitute one third of the total weight of dry matter. However, the proportion of seed and lint to other parts of the plant varies widely according to the luxuriance of growth and other conditions. Doubtless the seed and lint together often constitute less than one third of the total weight of the plant.

The above statements are based on the following figures, giving the average results of a chemical study of the different parts of the cotton plant as made by B. B. Ross at the Alabama Experiment Station (*Bulletin*, No. 107), and by J. B. McBryde at the South Carolina Experiment Station. (Tennessee Experiment Station *Bulletin*, Vol. IV, No. 5.)

The following table shows the amounts and proportions by weight of the different parts of the mature dry cotton

plants growing on an acre where the yield of lint is 300 pounds:

TABLE IX. AMOUNTS AND PROPORTIONATE WEIGHTS OF DIFFERENT PARTS OF COTTON PLANTS

	POUNDS DRY MATTER PER ACRE	PER CENT OF TOTAL WEIGHT OF DRY PLANT
Seed . . . . .	580	21.77
Lint . . . . .	300	11.35
Roots . . . . .	190	7.03
Stems . . . . .	631	23.80
Leaves . . . . .	571	21.58
Burs . . . . .	344	14.55
Seed and lint combined . . . . .		33.12

194. Amounts of nitrogen, phosphoric acid, and potash in the different parts of the cotton plant. The following table shows that to produce a crop of 300 pounds of dry lint and the other parts associated with this amount of fiber there were required about 42 pounds of nitrogen, 13 pounds of phosphoric acid, and 35 pounds of potash. The figures are reached by averaging the analyses made by Ross and McBryde, and are here given merely for reference:

TABLE X. AMOUNTS OF FERTILIZER CONSTITUENTS REQUIRED TO PRODUCE A CROP OF 300 POUNDS OF LINT

	DRY MATTER PER ACRE (Pounds)	NITROGEN (Pounds)	PHOSPHORIC ACID (Pounds)	POTASH (Pounds)
Lint . . . . .	300	0.63	0.23	2.00
Seed . . . . .	580	19.01	6.88	6.68
Burs . . . . .	344	3.75	1.44	11.71
Leaves . . . . .	571	13.25	2.64	6.35
Roots . . . . .	190	1.21	0.36	1.96
Stems . . . . .	631	4.52	1.25	6.44
Total . . . . .	2656	42.37	12.80	35.14

## PRINCIPAL USES OF COTTON

**195. Uses.** Cotton is utilized to a greater extent than any other vegetable fiber for clothing. Wool is the only other fiber that approaches cotton in the extent of use for this purpose. Cotton is adapted to the manufacture of a greater variety of textile fabrics than any other fiber. When it is treated with certain chemicals, or mercerized, the fabric takes on a glossy appearance and becomes a fair imitation of silk.

Cotton is much more extensively used than linen, jute, and other vegetable fibers because of: (1) the readiness with which cotton fibers absorb dyes, and (2) the peculiar twisted structure of its fibers, so favorable to ease of spinning and strength of thread.

The seeds constitute a valuable feed for cattle and sheep. They are usually fed raw but sometimes they are boiled to be fed to dairy cows. After the seeds are ground in the oil mills, the hulls are separated and used as cattle feed.

From the "meats," or hulled and ground seed, cottonseed oil is expressed by means of powerful hydraulic presses. This oil finds use as a human food, especially as a constituent of compound lard, oleomargarine, salad oils, and the like, as a lubricant, as a constituent of paint, in the manufacture of soap, and in almost all ways in which other oils are employed. After the extraction of the oil, the residue constitutes one of the most nutritious of feeds for cattle and sheep. It is fed either in the form of cake (lumps), or more frequently this cake is ground, thus forming cottonseed meal. Large amounts of cottonseed meal are also used as fertilizer.

Cottonseed meal as a feedstuff is chiefly used for cattle and sheep. It exerts a specific toxic effect on hogs when fed

in quantity for a certain length of time. Ill effects are seldom observed in less than four weeks, and they are usually shown in the periods between the thirtieth and fortieth day after the feeding of cottonseed meal is begun. Fermenting the meal seems to decrease this danger, as probably does also the feeding of green food or copperas at the same time. Cottonseed meal is injurious to young calves and probably to most very young animals.

### LABORATORY EXERCISES

From the tables on page 186 calculate for an acre producing 200 pounds of lint what would be the probable weight of (a) dry stems, or stalks; also (b) the number of pounds of nitrogen lost if the stalks, roots, and burs of a crop of this size are burned, assuming that these parts of the plant decrease at the same rate as the yield of lint.

### ADVANCED TOPICS

A. Determination of the proportions of hulls to meats in large and small cotton seeds.

B. Field work to determine under boll-weevil conditions the air-dry weights of leaves and immature forms and the probable value for pasturage of an acre of picked-over cotton plants.

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## CHAPTER XIII

### COTTON — SPECIES AND VARIETIES

As cultivated in the principal cotton-producing countries, all the important species of cotton are annuals, maturing seed before cold weather and being killed by frost. In very warm countries plants of some species live for a number of years.

**196. Family and genus.** The cotton plant is one of the mallow family (Malvaceæ). This family also includes: okra; a number of cultivated flowers, such as hollyhocks, hibiscus, and althea; a considerable number of not very troublesome weeds; and certain plants the bark of which affords useful fiber. The mallow family includes both herbs and shrubs or trees. All the plants within it have flowers with five petals and numerous stamens, the supports for the stamens forming a tube around the pistil; there are usually several leaflike parts (bracts) just below and around the flower, three of these forming in cotton what is known as the square. The leaves are alternate, and the veining begins at a common point near the base of the leaf blade, that is, the leaves are palmately veined.

The genus, or subdivision of a family, to which the cotton plant belongs, is *Gossypium*. In this genus the stigmas, grown together, usually number three to five, according to the number of locks which will be contained in the mature fruit, or boll. The leaves are lobed, the size and shape of the lobes varying in the different species.

## SPECIES

**197. Principal species of cotton.** Botanists differ widely as to the number of species of *Gossypium* and as to the name that should be applied to certain species. Moreover, some cultivated cottons are crosses, or hybrids, between two species, thus increasing the difficulty of properly naming each kind. For example, until recent years it was customary to refer to the present commonly grown upland cotton in the United States as *Gossypium herbaceum*, a name now given to one of the Asiatic cottons. Watt, in *Wild and Cultivated Cotton Plants of the World*, assumes that for a time the early colonists did grow this species in Virginia, but that before cotton became an important crop it was displaced by the present type of American upland cotton; the former, he thinks, still influences American upland cotton through its hybrids. The latest investigators favor the name *Gossypium hirsutum* to include both the ordinary, or short-staple, cotton of the United States and also the long-staple upland cotton of this country.

As many as fifty-four species of *Gossypium* have been described and named, but most botanists reduce the species to a much smaller number.

The following may be regarded as the species most important to the world's agriculture, commerce, and manufacture:

*American group:*

(1) *Upland cotton* (*Gossypium hirsutum*). This is the ordinary cotton of the southern part of the United States, including the long-staple class.

(2) *Sea-island cotton* (*Gossypium barbadense*; so named from the island of Barbados). This affords the finest, longest, and most valuable of all cotton fibers.

(3) *Peruvian cotton* (*Gossypium peruvianum*). Its importance is not due to its cultivation in its home in Peru, but to its having become the principal cotton of Egypt. Although transplanted to Africa, it retains a closer kinship to American than to true Asiatic cottons.

*Asiatic group:*

(4) *Indian cotton* (*Gossypium obtusifolium*; so named because the lobes or divisions of the leaves are rounded or obtuse). This includes the best grades of Indian cotton, often called in commerce Broach or Surat cotton.

(5) *Bengal cotton* (*Gossypium arboreum*). This is another important cotton of India.

The members of the American group, including sea-island, ordinary upland, and Egyptian, cross freely among themselves. However, Gammie<sup>1</sup> in his experiments found that the American cottons did not cross with those of the Asiatic group. While there is undoubtedly difficulty in making most crosses between the American and Asiatic groups, Watt maintains that such crosses are possible.

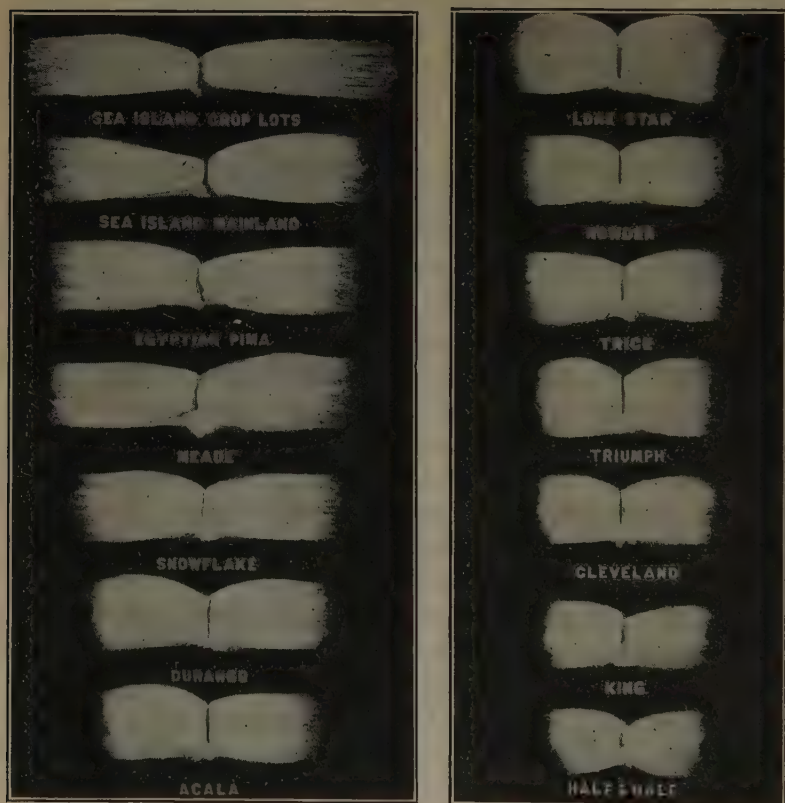
**198. American upland cotton** constitutes all of the cotton crop of the United States except the small amount of sea-island cotton grown near the South Atlantic and Gulf coasts. It forms the largest single item of export and brings into the United States more money than any other crop or single line of manufacture.

American upland cotton may be divided into two principal classes: (1) short-staple and (2) long-staple varieties. The chief distinction between these is in the length of lint (Fig. 98), that of short-staple being usually  $\frac{3}{4}$  to 1 inch, while long-staple, or "staple cotton," usually has a length of  $1\frac{1}{4}$  to  $1\frac{5}{8}$  inches.

Between these two groups, which are somewhat sharply

<sup>1</sup> Gammie, *The Indian Cottons*.

distinguished from each other, lies an intermediate class. The cottons of this class are called commercially "benders"



*Courtesy U. S. Dept. of Agriculture*

Fig. 98. — Fibers of certain species and varieties of cotton  
Reproduced actual size.

or "rivers." These names arise from the fact that this intermediate kind is grown chiefly on moist bottom land. Such soil has a tendency to lengthen the staple even of a short-staple variety. Moreover, there are varieties having

intermediate lengths of lint, even when grown on upland.

There are usually other differences between long-staple and short-staple cotton, though these are by no means universal distinctions. As a rule, the long-staple cotton plant is late in maturing, tall, and supplied with bolls that are slenderer and more sharply pointed than is the case with most short-staple varieties (Fig. 96). Long-staple cotton invariably has a lower percentage of lint; the yield of lint is less, frequently below 70 per cent of that yielded by short-staple varieties on the same grade and area of land.

The difference in price between long-staple and short-staple cotton varies greatly from year to year. Generally this difference, or premium, for long-staple is between 3 and 5 cents per pound.

**199. Sea-island cotton** is grown only in limited areas on or rather near the seacoast in South Carolina, Georgia, and Florida. It was generally regarded as a profitable crop only within a distance of about 100 miles from the coast. The coming of the boll weevil has been even more destructive to sea-island cotton, which matures late, than to the earlier maturing upland cotton.

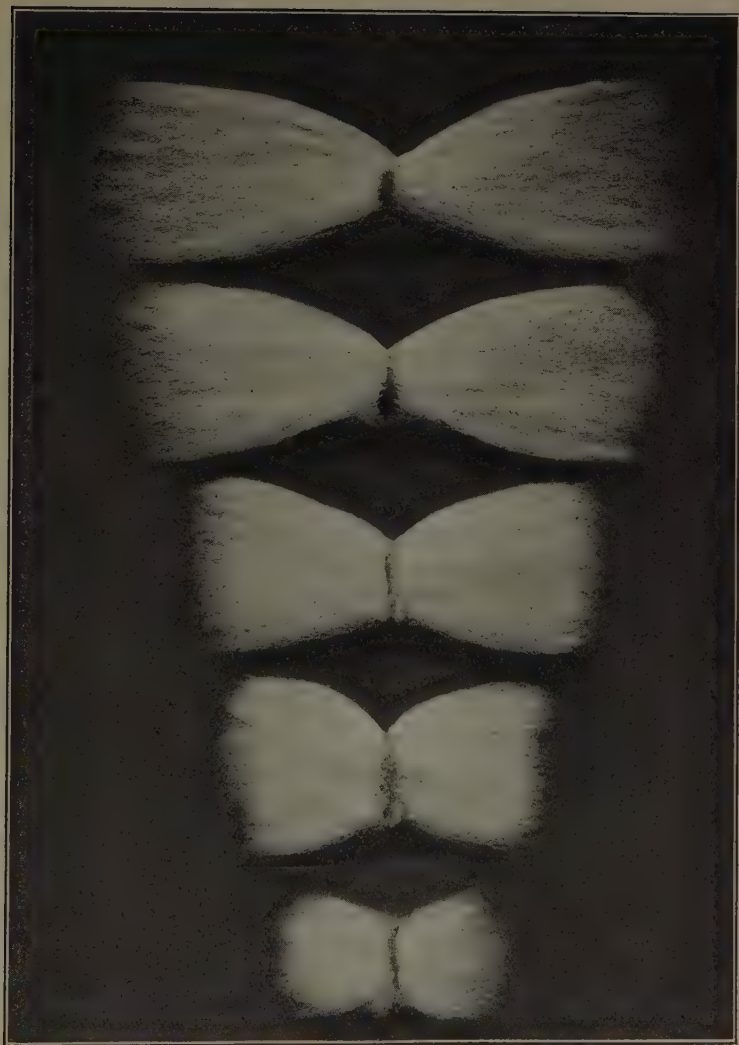
The sea-island cotton plant is distinguished from upland cotton chiefly by the following characteristics: (1) a taller plant, with longer, slenderer branches, and later maturity; (2) leaves with much longer and slenderer lobes; (3) absence of hairs from leaves and stems; (4) yellowish color of the fresh blooms and the presence of red spots near the base of each petal; (5) much smaller, slenderer boll, with usually only three, or sometimes four, locks; and (6) longer, finer fiber and the naked black seed nearly or quite free from fuzz.

The usual length of fiber is  $1\frac{1}{2}$  to 2 inches. In quality sea-island cotton is fine and silky. It is used in the manufacture of the most expensive cotton fabrics, such as laces, fine hosiery, and lawns. The price of this cotton is far above that of the highest grade of upland long-staple.

**200. Peruvian and Egyptian cotton.** True Peruvian cotton, including some leading varieties now grown in Egypt, has a brownish lint. The fiber of Egyptian cotton is longer than that of American upland long-staple but shorter and less valuable than that of the sea-island. It is an interesting fact that, though the United States exports millions of bales of upland or short-staple cotton, American manufacturers find it necessary to import annually a considerable amount of Egyptian cotton. This is because Egyptian cotton is needed for special purposes; for example, it is the kind best suited to the chemical treatment known as mercerization, by which a silky luster is imparted.

About the time of the World War there was produced on irrigated land in the dry climate of Arizona and the southern part of California a large amount of Pima (or acclimated Egyptian) cotton. Following the financial depression of 1920 Pima cotton has been to a considerable extent displaced by short-staple upland varieties, chiefly of the big-boll type. The change was brought about partly by fluctuations in market demands and prices. But the Pima cotton lost ground largely because it afforded smaller acre yields and because it cost about twice as much to pick a pound from its small bolls as to pick short-staple varieties.

**201. Asiatic cottons.** The cotton grown in India and elsewhere in Asia is less productive and has a shorter fiber than American short-staple cotton. The colors of the flowers are various, and the forms of the plants and of the leaves differ from those of any of the American groups.



*Courtesy U. S. Dept. of Agriculture*

**Fig. 99. — Fibers of principal commercial types**

**From top to bottom, sea-island, Egyptian, upland long-staple, upland short-staple, and Asiatic.**

## VARIETIES OF AMERICAN UPLAND COTTON

There are many hundred names to represent varieties of cotton. The Alabama Experiment Station has tested more than three hundred of these so-called varieties and found that a large proportion of them are merely synonyms. However, it is probable that the number of distinct varieties, each differing from the other in one or more items of agricultural or botanical importance, exceeds one hundred.

**202. Reasons for variation.** Among the causes which have led to this multiplication of varieties are the following:

(1) Modifications of the plant resulting from continuous selection or from special soil and climatic conditions.

(2) Artificial crosses intentionally made with a view to creating new varieties combining some of the qualities of both parents.

(3) Natural hybrids resulting chiefly from the carrying of pollen by insects from the flowers of one variety to the stigmas of another.

(4) Names have been needlessly multiplied, both intentionally and unintentionally; so some varieties may be purchased under half a dozen different names.

**203. Varieties of cotton not easily recognized.** The differences between the numerous agricultural varieties are so slight that even an expert is unable to identify with certainty any but those varieties having the most definite characteristics. Indeed, the description of any variety will not apply to all the plants in it, but is to be taken rather as a general, or average, portrayal.

**204. Classification of varieties.** The study of varieties may be simplified by arranging them in a small number of groups, as is done in the subjoined scheme of classification. The American upland short-staple cottons may be divided

into six classes; to this is added a seventh division to include short-staple varieties of a character intermediate between any other two groups. An eighth group differs from all the others because its members possess a long staple.

Group 1. Cluster type (Fig. 100)

Group 2. Semicluster type

Group 3. Rio Grande, or Peterkin, type

Group 4. Early varieties of the King type (Fig. 101)

Group 5. Big-boll type (Fig. 102)

Group 6. Long-limbed type

Group 7. Intermediate varieties

Group 8. Long-staple upland varieties (Fig. 103)

The lines of separation between these groups are not distinct; one group gradually merges into another.

**205. Cluster group.** The varieties belonging here are easily distinguished (1) by the extreme shortness of the fruit limbs in the middle and upper parts of the plant and (2) by the tendency of the bolls to grow in clusters of two or three (Fig. 100). These varieties are now much less popular than formerly.



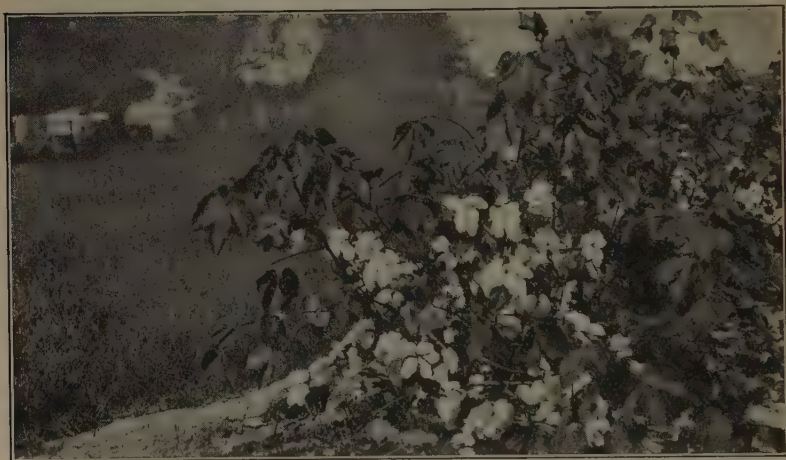
Fig. 100. — A fruiting limb of a cluster variety

**206. Semicluster group.** The varieties of this class present somewhat the appearance of cluster cottons, but the fruiting limbs in the middle of the plant are of short to medium length. The bolls, though close together, are not borne in clusters. There is much diversity among the semicluster varieties in size of boll, size of seed, and percentage of lint.

**207. Rio Grande group.** The varieties of this group are now but little grown since the cotton-boll weevil has placed

its ban on late to medium kinds. Their most distinctive characters are a lint percentage of 35 to 40 and very small dark seeds with only a partial covering of fuzz. The bolls are small. Peterkin was the most widely grown variety.

**208. Early King-like group.** The plants (Fig. 101) are often small to medium in size. The fruit limbs are slender and often crooked. The vegetative branches are short or wanting, and the bolls are small. The leaves are small with



*Courtesy N. C. Experiment Station*

**Fig. 101.** — A plant of the King variety

sharp lobes and the seeds are usually small and covered with fuzz of various shades. Some of the blooms are marked with red spots near the inner base of each petal. The King and its synonyms and related varieties constitute the earliest of the commonly grown American upland cottons.

The chief faults of these varieties are the small size of boll, the shortness of fiber, and the tendency of the seed cotton to fall from the burs.

**209. Big-boll group.** The one characteristic serving to identify the varieties of this group is the large size of the boll. While this varies with many conditions, they are here considered large if sixty-eight or fewer mature bolls yield one pound of seed cotton. This group includes the following overlapping subdivisions: (1) storm-proof big-boll cottons; (2) big-boll varieties having plants of the



*Courtesy U. S. Dept. of Agriculture*

**Fig. 102. — A plant of Triumph cotton**

**This variety belongs to the Texas big-boll group.**

shape that characterizes the semicluster group; and (3) big-boll varieties having neither marked storm-resistance nor semicluster shape of plants.

Examples of storm-proof big-boll cottons are Triumph (or Mebane) (Fig. 102) and Rowden.

**210. Long-limbed group.** In this class, now nearly extinct, the plants grow to large size and have long limbs with long internodes. They are too late for boll-weevil conditions.

**211. Intermediate group.** This group is provided merely as a matter of convenience to include varieties that are too



*Courtesy U. S. Dept. of Agriculture*

**Fig. 103.** — A plant of Durango cotton  
An upland long-staple variety.

nearly halfway between any other two groups to be assigned to one of them.

**212. Long-staple upland group.** The superior length of staple is the distinguishing characteristic of this group

(Fig. 103). The lint usually measures  $1\frac{1}{8}$  to  $1\frac{1}{2}$  inches, and the percentage is low, generally less than 30. The bolls are likely to be more or less acutely pointed. Examples are Express and Meade.

Especially on upland soils the long-staple varieties are usually less productive than short-staple cotton, and here they afford a lint shorter than that produced by them on moist rich bottom land.

**213. Varying productiveness of varieties.** The most important fact brought out by a study of the numerous variety tests made at all the Experiment Stations within the Cotton Belt is that there is no one variety uniformly most productive under all conditions of soil and climate. As a general rule, the varieties that have proved most productive since the appearance of the boll weevil have been those that are medium early or early. Moreover, earliness, which is required for high productiveness in the presence of the boll weevil, is generally associated with rather short length of lint.

**214. Leading varieties at Southern Experiment Stations.** The following lists, based on correspondence, make mention of those varieties which have most frequently taken high rank in yield of lint per acre in the years since the coming of the cotton-boll weevil:

STATE OR STATION	VARIETY
Alabama . . . . .	Cook (various strains)
	Cleveland (various strains)
(for wilt-infested fields) .	Toole and Cook 307-6
Arkansas . . . . .	Triumph and Cleveland
	Lone Star
	Acala and Rowden
	Deltatype and Delfos
(Northern) . . . . .	Trice and Express

STATE OR STATION	VARIETY
Georgia (Athens) . . . .	College No. 1 Piedmont Cleveland Wannamaker Cleveland
Georgia (Experiment) . . .	Wannamaker Cleveland Cleveland (various other strains) College No. 1 Cook Poulnot (for wilt-infested fields) . Toole Lewis 63 (for wilt-infested fields) . Dixie Triumph Delta-type Webber (long-staple)
Kentucky (southwestern corner)	Express Acala Trice Mexican Big-Boll
Louisiana (Baton Rouge) . .	Cleveland Wannamaker Cleveland Trice Mexican Big-Boll Dixie Triumph
Mississippi . . . . .	Cleveland (various strains) Trice Delfos Cook (various strains) Lone Star
North Carolina . . . . .	Mexican Cleveland Lightning Express Edgecomb Cook (for extreme northern part) King No. 29
Oklahoma (especially for western part) . . . . .	Mebane, or Triumph (especially for eastern part) Acala (especially for lowlands) . Lone Star (especially for uplands where growing season is long) . Rowden

STATE OR STATION	VARIETY	
South Carolina . . . . .	Cleveland	
(for wilt-infested fields) .	Dixie Triumph	
	Delta-type Webber (long-staple)	
	Express (long-staple)	
Tennessee . . . . .	Trice	
	Express (long-staple)	
(for southern border) . .	Cleveland and Mexican Big-Boll	
Texas . . . . .	Mebane	Truitt
	Lone Star	Rowden
	Kasch	Belton
	Bennett	Acala

**215. Descriptions.** Below may be found brief descriptions of some of the varieties of short-staple cotton which have been most prominently before the public during the decade ending in 1923 by reason of high yield, widespread popularity, or unique and valuable characteristics.

*Cook.* There are a number of strains. The bolls of most of these are barely large enough to place Cook in the big-boll class. The plants are somewhat variable in form and appearance. The special merits of Cook are its very high rank in acre yield of lint shown in a large proportion of variety tests; its very high percentage of lint, sometimes exceeding 40; and its early to medium maturity. Its greatest fault is its susceptibility to boll rot (anthracnose). It is lacking in storm resistance. The seeds are small and covered with fuzz, giving a grayish appearance. The lint is rather short, usually  $\frac{7}{8}$  of an inch.

As the result of more than fifteen years of systematic selection, the Alabama Experiment Station developed several strains of especially high productiveness. Among these are Cook No. 588 and Cook No. 1010, the descendants

of which are widely grown in that state. Another of these is Cook Wilt-resistant; its special value is its resistance to cotton wilt.

*Cleveland.* This variety is represented by a number of strains, some of which fall within the big-boll group. Cleveland somewhat resembles Cook but has less susceptibility to boll rot. Like Cook it has been a frequent leader in the yield of lint as shown in Experiment Station tests.

*Triumph, or Mebane.* This variety was developed in the southern part of Texas from a cotton of the storm-proof group. Its special claims to prominence are the large size of bolls, medium maturity, and rather high percentage of lint. While it has not usually stood first in variety tests east of the Mississippi River, it has frequently been rather high in productiveness. In many sections it is justly a favorite because it combines a number of good qualities.

*Rowden* is a big-boll storm-resistant variety similar to Triumph and popular in Texas.

*Lone Star* is a big-boll variety extensively grown in some parts of Texas.

*King.* This variety, like all the others of the same group, is prized for its extreme earliness, which is offset by the small size of bolls, the tendency of the seed cotton to fall from the burs, and the shortness of the staple. King is more extensively grown in the northern fringe of the Cotton Belt than elsewhere. King and its synonyms have usually ranked rather low in Experiment Station tests, both before and since the coming of the boll weevil. The plants are small and the leaves small and rather sharply lobed. A distinguishing mark of this variety is the presence of a crimson spot on the inside of the petals of some of the flowers.

## LABORATORY EXERCISES

(1) For at least three varieties locally grown, record in three vertical columns of your notebook the points in which they differ in regard to: (a) size and shape of full-grown leaves; (b) size and shape of green bolls; (c) general shape of plant, or lengths of lower and middle limbs.

(2) Draw to exact size the outlines of a typical grown boll of each of at least three varieties, measuring and recording the dimensions of each.

(3) In the laboratory comb out the lint of a single seed of each of at least three varieties, pasting the seed and adhering lint to cardboard that has been blackened with ink or covered with a black cloth. Then measure and record for each the average length of lint that grows from the thicker portion of the seed. What variation, if any, is there in length of lint from near the two ends of the same seed?

(4) Record any other differences between the varieties of cotton that are examined in a field trip.

## ADVANCED TOPICS

A. A laboratory study of size of boll and length of staple produced by many varieties and by the same variety grown under varying conditions of soil and climate.

B. A library study of results of variety tests made in the presence of the boll weevil.

C. A library study of the relative acre yields of lint as between the best long-staple and most productive short-staple varieties.

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## CHAPTER XIV

### COTTON BREEDING

An important part of crop growing is to maintain the excellence of types and varieties and to improve the plants by constant attention to approved methods of breeding. Cotton is no exception to this rule.

**216. Deterioration of cotton is easy.** A large proportion of the farmers of the Cotton Belt plant impure, mixed, and otherwise inferior cotton seed. Even where a start is made with a pure variety, the cotton usually "runs out," or deteriorates, in a few years. This is not because soil or climate is unfavorable; the depreciation in productiveness and quality is generally due to one or more of the following reasons:

(1) Failure to select plants as carefully for seed as did the person who originated or improved the variety.

(2) Mixing of the seed at public gins with inferior seed.

(3) Cross-pollination by insects bringing pollen from inferior varieties or from unimproved (scrub) cotton.

(4) The planting of seed obtained in the last picking many of which are immature, light and defective, or from late, poor plants.

Nowhere in the Cotton Belt is there any necessity for short-staple cotton to deteriorate. If it does become less valuable, the cause will be found in want of due care to secure good seed for planting.

**217. Improvement of cotton seed profitable.** A study of the results of any tests of varieties of cotton reveals a wide difference between the yields of the most productive varieties

and of the least productive. The difference is even greater between common or unimproved cotton and the best varieties. It is probably safe to estimate that a suitable improved variety will, as a rule, yield at least 20 per cent more lint to the acre than will unimproved or scrub cotton.

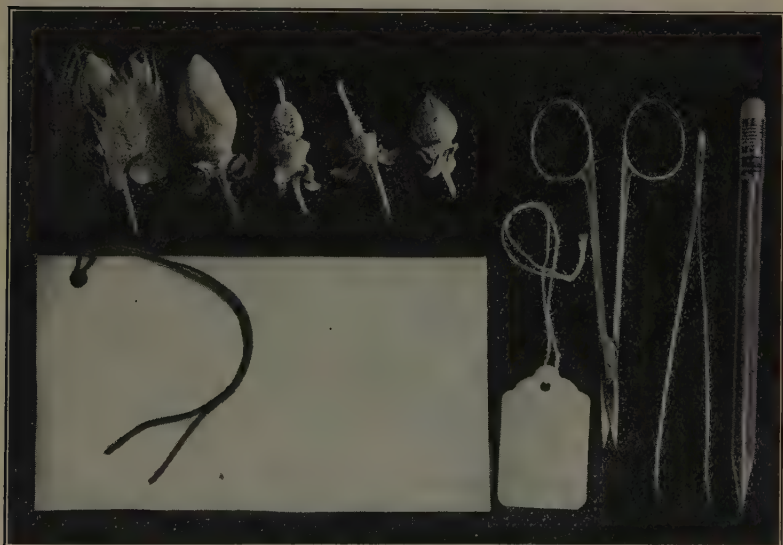
**218. Crossing *versus* selection as a means of improving cotton.** In improving cotton or any other plant, reliance is placed on selection or on hybridizing or on a combination of both of these processes. Selection attains the quickest results, especially if a beginning is made with a good established variety. Selection is the only process that farmers, as a rule, need to practice.

Crossing of two widely different individuals or varieties is sometimes performed in the hope of uniting in the offspring the good qualities of both. The chances are much against securing this desired combination in most of the plants of the progeny; even when the combination is secured in one plant, it is not inherited by the larger part of its offspring.

After a cross is made, the plants grown from such crossed seed must be selected carefully for a number of years before there is much uniformity among the different plants. One need scarcely expect the type to become well fixed in less than five years after making the cross. Therefore, crossing is scarcely practicable for most farmers; but it can be used to a limited extent by a plant breeder, that is, by one who devotes a large proportion of his time to the improvement of plants.

**219. Directions for crossing cotton.** Near sunset the pollen cases (anthers) are removed from large flower buds that would open the next morning. The removal of the anthers is most conveniently done by cutting away the greater part of every petal, and then carefully removing

every anther, either with a small pair of pincers, a small pair of scissors, or with the blade of a pocket knife, taking care not to bruise the pistil around which the stamens grow. The anthers when removed are still closed: if any



*Courtesy U. S. Dept. of Agriculture*

**Fig. 104. — Outfit for cotton crossing**

At the top are four blossom buds showing the different steps in the operation of emasculation and the small boll which results in a few days after the cross is made.

have begun to drop their pollen, the bud is too far advanced for crossing. As soon as the anthers are taken out, a small paper bag is pinned or tied over the mutilated flower to keep insects from bringing to the stigma the pollen from some unknown cotton plant.

Next, choose the plant that is to furnish the pollen, and over its buds, nearly ready to open, tie a paper bag to exclude insect visitors. The next morning, usually about

nine o'clock, the stigma on the mutilated flower will be ready to receive the pollen from the chosen sire plant. This readiness will be shown by the stickiness of the upper portion of the pistil, that is, the stigmas. At about the same time that the stigmas become receptive, the anthers in other flowers will have begun to burst, setting free their pollen.

There are several methods of placing the pollen on the flower from which the anthers have been removed. One consists merely in pulling the entire flower bearing the pollen, and rubbing its anthers lightly over the stigmas of the mutilated bloom, until some of the grains of pollen are seen to adhere to all sides of the pistil. Then the paper bag is again placed in position, to be left over the mutilated flower for about five days, or until a young boll has developed. This boll must be labeled carefully by means of a small tag, so that at harvest time the crossed boll may be distinguished from others.

**220. Variation and selection.** The individual plants within a single variety differ considerably. Still greater is the divergence between individual plants of unimproved cotton. This tendency to vary makes constant improvement possible, for as long as a few plants are distinctly superior in any quality, there is the possibility of bringing the average much nearer to the standard of the best plants.

It is highly desirable that any pure variety of cotton should possess the maximum degree of uniformity among the individual plants. This uniformity is much more quickly and completely secured by beginning with a variety already considered as pure. Hence any person desiring to improve cotton should first of all become familiar with the best varieties, and from these he should choose for improve-

ment that one which possesses the greatest number of qualities desired and on which the fewest new qualities need to be engrafted.

**221. The simplest method of selection.** The following method of selection is recommended as practicable for most farmers who can not afford to devote much attention to



Fig. 105. — A field of Dixie Triumph, a wilt-resistant variety

cotton breeding, but who desire to maintain or slowly improve the purity and excellence of any good variety:

At the first or second picking let one of the most careful of the pickers precede the others and pick into one bag the seed cotton from the best plants.

The plants chosen by this picker must be very productive, and they should possess in addition the other qualities desired; for example, earliness and a certain size of boll. All plants chosen for seed should be uniform in the appearance of the plant and in the other qualities desired.

**222. Principal qualities desired in the plant.** A careful person engaged in selecting cotton soon becomes so expert that, as he walks along the row, he can detect at a glance the most promising plants. Then he should make a hasty decision as to whether each productive plant combines the following important points:

- (1) Desired size of bolls.
- (2) A large number of bolls.
- (3) The desired degree of earliness.
- (4) The shape of plant characteristic of that variety.
- (5) Freedom from disease, such as boll rot, rust, and cotton wilt (Fig. 105).

Each farmer should decide for himself whether it is practicable for him, in selecting cotton, to consider other qualities not so readily detected, such as length of lint and proportion of five-lock bolls.

**223. Defects in bolls.** In selecting seed for planting, either by the simple method now under discussion or by a more careful process to be described later, no boll should be picked for seed that has any of the following defects:

- (1) Spots on the hull or bur, due to disease.
- (2) Any imperfectly developed lock, or any lock not fully open.
- (3) Diminutive size of boll.

A boll with disease spots or with a defective lock is likely to convey the germs of disease to the next crop.

**224. The seed patch.** The cotton picked for seed from the best plants as directed above should be carefully ginned to avoid any mixing at the gin. The next season the selected seed thus obtained should be planted thinly in a seed patch having uniform soil and separated as far as possible from any other cotton.

Each year a similar seed patch should be planted with

seed selected from the best plants of the preceding year's seed patch. The remaining seed, after the best plants have been picked over once, may suffice to plant the entire farm.

The method of selection described in the last few paragraphs is practicable on almost any farm, whether large or small. However, this method alone will serve rather to maintain established excellence than to afford any notable and rapid improvement in the variety, which must be effected by a more painstaking process (228).

**225. Qualities needing improvement.** Selection or breeding is capable of improving the cotton plant in every desirable quality. Among those directions in which improvement should be sought are the following:

- (1) Increase in the yield of lint.
- (2) Increased earliness.
- (3) Increase in size of boll (Fig. 95).
- (4) Greater length of lint (Fig. 98).
- (5) More uniformity in the length of lint (Fig. 97).
- (6) Improvement in the form of plant or method of branching.
- (7) Increase in percentage of lint of some varieties.
- (8) Greater resistance to diseases (Fig. 105).

**226. Some antagonistic qualities.** Some of the qualities just mentioned tend to exclude other desirable ones. The following pairs of qualities are generally antagonistic; that is, they are rarely, if ever, found in the same individual plant:

- (1) Extreme earliness is opposed to very large bolls.
- (2) Extreme earliness is usually not associated with the highest yields of lint, except when the fruiting season is shortened by early frost or by boll-weevil injury.
- (3) Great length of lint excludes the probability of a high percentage of lint.

(4) A high percentage of lint is seldom found in varieties or strains having large seeds.

As a rule, any progress in improving one of these characters results in a decrease in its antagonistic quality. However, an occasional single plant may constitute an exception and combine, to a certain extent, these opposing qualities. Such exceptional plants are exactly those that the plant breeder is seeking to evolve or to discover and then to perpetuate in their purity.

Although certain pairs of desirable qualities are antagonistic, yet the cotton plant has many useful characters that can readily be improved together without mutual injury.

**227. Breeding for a small number of qualities.** The most rapid improvement in any character is secured when plants are selected for seed with chief reference to a very small number of desirable qualities. For example, if an increased size of boll is the only point aimed at, any given field will contain more plants filling this requirement than specimens answering the needs of a man who wishes a combination in the same plant of three qualities, such as large size of boll, small seed, and long lint.

Therefore, it is wise to make one quality the leading one, so that every plant selected shall possess this to a high degree; but there should also be in mind several secondary qualities, which the selected individuals should possess to at least a moderate degree.

The important practical lesson from the above principle is to continue selection year after year with the same chief object in mind until that end is attained. One should not select one year chiefly for size of boll and the next year mainly for length of lint; but the same aim and desired quality should be kept in mind from year to year. After this character is fixed, it is time enough to take another

one as the principal object through another series of years.

From this discussion it follows that it is important to start with a pure variety that already possesses most of the qualities desired.

**228. Plant breeders' methods of improving cotton.** In order to make very great or very rapid improvement in a variety or strain of cotton, it is necessary to practice a method requiring much more time and pains than can be spared by any except the few men who make a specialty of plant breeding. This method is called the "plant-to-row method." It is based on the fact that plants may be excellent by reason of either (1) favorable surroundings (environment), or (2) their inherent, or self-contained, excellence.

*Superiority due merely to favorable environment*, such as an extra share of fertilizer, abundant space, and other advantages, *is not hereditary*; but *inherent excellence is hereditary*. It is usually difficult or impossible to determine whether the superiority of a selected plant is accidental (due to favorable environment) or inherent. This question remains unsettled whenever seed from a number of individuals are planted together, as in the simplest method of selection before described.

However, by keeping the seed of each specimen separate and planting them on a separate row, the next year the parent plant of inherent or inheritable excellence is readily determined, for its descendants almost uniformly show the desired quality; while a row grown from a parent plant that was productive merely because of favorable environment does not show the good qualities of the parent. Hence selection must be made thereafter only from those rows on which the plants exhibit the proof of having inherited the

good quality of their parent, this fact creating the presumption that they also are prepotent, or able to transmit their good qualities to the next generation.

*Details of the plant-to-row method of cotton breeding.* In the best field of the desired variety select each year 100 plants, or as many as can well be ginned and planted separately. Place a tag bearing a number on each selected plant before picking. On a large strong paper bag write a similar number. Whenever a picking is made, place the seed cotton from plant No. 1 in bag No. 1, and so on for each selected plant. After weighing the seed cotton from each plant, reject those that are far below the average productiveness. For accurate work it is desirable to gin the seed cotton of each plant separately, which is best done in a specially constructed very small gin.

If ginning is not practicable, selection must be made among the picked plants merely on the basis of the weight of seed cotton; in this case the unginned cotton may be planted in hills at uniform distances apart, a lock or half a lock in a hill. When thus planted extreme care must be taken to pack the moist soil over each piece of seed cotton, otherwise the stand will be poor.

In the fall select the best plants on what seem to be the best rows, and then weigh the remainder of the crop on each row separately so as to determine which rows are really the best, as shown by the total yields.

Plant the second year on very uniform land a similar plant-to-row patch, usually containing 20 to 100 rows, each planted with the seed of one of the best plants from the few best rows of the year before. Make all rows of uniform width and plant the field in checks so that every plant may have exactly the same amount of space. The breeding patch should always be on uniform land and

removed as far as possible from any other kind of cotton so as to avoid cross-fertilization.

The following diagram (Fig. 106) shows the steps from year to year:

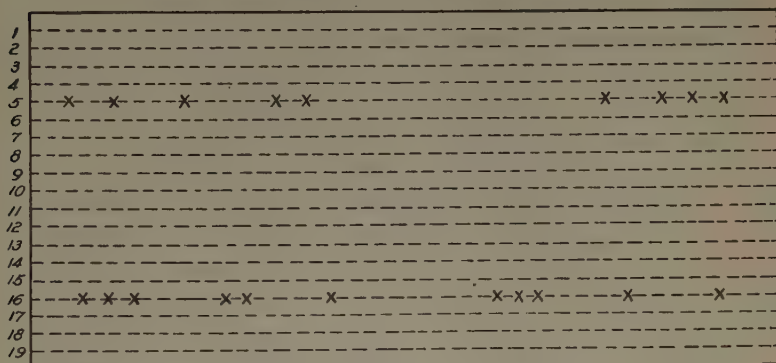


Fig. 106. — Diagram of rows of cotton for plant-to-row selection

Each horizontal line represents a row in the plant-to-row test each year. An "x" represents a selected plant on one of the best rows. Each plant-to-row patch is planted with seed from these best individuals, the seed of each plant occupying a separate row.

The next diagram (Fig. 107) shows the possibility of obtaining in three or four years from a single original plant enough seed to plant an entire farm.

**229. Plant breeding a specialty.** Most farmers can practice the simple method of selection first described, but few will be able to give the time and pains to the careful work of the plant-to-row method. Yet so much superior to average seed of even the purest varieties are seed produced by the plant-to-row method that farmers can better afford to pay a fancy price for small amounts of seed thus improved than to plant ordinary seed. Undoubtedly in the future

the tendency will be for plant breeding to become a business or a profession requiring the entire time of painstaking trained men, from whom farmers will find it more profitable to buy pedigreed seed than to attempt elaborate plant breeding in connection with ordinary farm work.

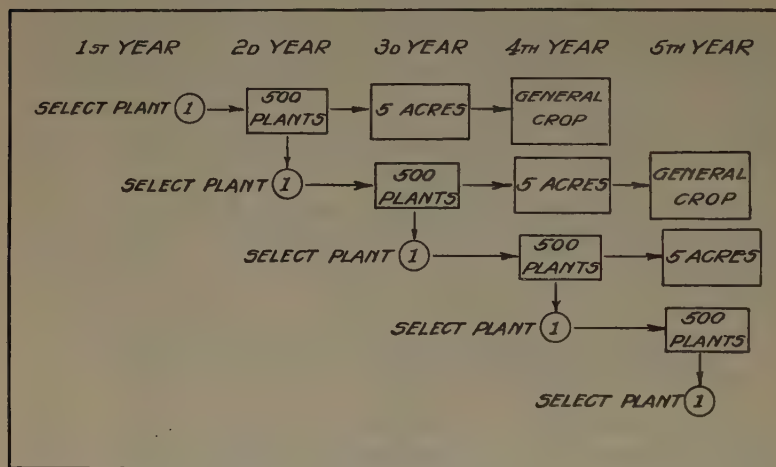


Fig. 107. — Diagram showing method of selecting and increasing cotton plants

**230. Size of seed for planting.** Several experiments have shown that by separating and planting only the heavy seed, the percentage of germination is increased. At the Alabama Experiment Station large seed from large-seed ancestry were planted year after year in comparison with light seed from light-seed ancestry. For the first few years little difference was apparent. However, after a number of years the large seed showed decided superiority in promptness of early growth and in size, vigor, and productiveness of plants.

It does not follow that, because the largest seed within a given variety are superior to the smaller seed, that variety is best which has the largest seed. Indeed the opposite is

often true; the high percentage of lint that is frequently found in varieties with small seed often makes them more productive of lint than varieties with large seed.

*Methods of separating large and small or heavy and light seed.* As cotton seed come from the gin, covered with a coat of fuzz, they tend to cling together in masses. This renders it difficult, without previous treatment of the seed, to separate the largest from the others.

Webber and Boykin recommended (United States Department of Agriculture *Farmers' Bulletin* No. 285) the following treatment of the seed: A thin flour paste is poured on the seed, which are then stirred or otherwise agitated until every seed is covered. The fuzz is thus pasted down to the hull. After drying, the seed are in condition to be separated easily in a fanning machine especially constructed so as to blow out the lighter seed. Those which have been treated with paste can be planted more thinly than otherwise, which is an advantage in the subsequent thinning of the plants.

The *delinting* of the seed, which consists in reginning them as is commonly done by oil mills, also makes it somewhat easier to separate the individual seeds.

### LABORATORY EXERCISES

(1) If practicable, make a number of crosses, preferably among varieties having easily recognizable features; pupils who are especially interested may wish to plant the resulting seeds and to note the diversity among the plants.

(2) Students should copy the score card below and by its aid score the plants — preferably by pairs — of several varieties. This exercise needs frequent repetition, not so much to familiarize the pupils with the score card (which may be considerably modified for special objects), but for the purpose (*a*) of directing more careful attention to the characteristics of the different varieties, or strains, and (*b*) to train the eye and the mind to the prompt recognition of the defects and valuable characteristics of any cotton plant observed.

## SCORE CARD FOR COTTON

Use the following score card adapted by the author for the use of students of the Alabama Polytechnic Institute:

	PERFECT SCORE
1. Form, short-jointed, well-branched, indicating fruitfulness . . .	15
2. Yield* (standard 1 bale or more per acre):	
(a) Size of bolls (standard 60 per pound; 1 point deducted for each additional 5 bolls required per pound of seed cotton)	15
(b) Per cent lint (standard 40 per cent for short-staple varieties; 32 per cent for long-staple; 1 point cut for each 1 per cent below standard)	10
(c) Number of mature bolls per plant . . . . .	15
(Standard, unfavorable conditions . . . . . 20)	
(Standard, medium conditions . . . . . 60)	
(Standard, good conditions . . . . . 100)	
Total yield (a and b and c); or weighed yield seed cotton times average per cent lint of that variety . . . . . 40)	
3. Earliness (standard being the earliest plants of King) . . . . .	10
4. Hardiness of plant towards disease . . . . .	3
5. Storm resistance . . . . .	2
6. Completeness of opening and ease of picking . . . . .	2
7. Lint:	
Length of lint (standard, upland, 1 to 1½ inches; long-staple, 1½ inches) . . . . .	8
Uniformity in length of fibers on same seed . . . . .	8
Strength . . . . .	3
Fineness . . . . .	3
Color . . . . .	2
Maturity . . . . .	2
8. Uniformity of seed in size, color, etc. . . . .	2
Total . . . . .	100

## ADVANCED TOPICS

A. A field study of the extent of variation in the cotton plant, both under uniform and under diverse environment.

B. A library study of the characters of the cotton plant that are inherited as dominant, recessive, or blended qualities.

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## CHAPTER XV

### COTTON — SOILS AND FERTILIZERS

Cotton is a most adaptable plant. Almost any land in the Cotton Belt — from light sandy to stiff clay — will produce a crop, provided it is well drained and, if poor, supplied with the necessary kind and amount of fertilizing materials.

**231. Soil range.** A large proportion of the American cotton crop grows on land too sandy, dry, and poor to be thoroughly satisfactory for corn. Indeed, a large area of cotton grows on land too poor to yield a profit even from cotton. These unprofitable areas, these "robber acres," are the source of much loss to cotton farmers. They could be devoted more advantageously to pasture or to leguminous plants. On sandy land the cotton plant is much more subject to injury from cotton rust than on loam or clay soils.

On some very rich moist bottom land, cotton makes a stalk of excessive size without a corresponding development of fruit. Therefore, such lands are not favorable for cotton but may be more advantageously devoted to the production of corn, hay, or pasturage.

#### GENERAL CONSIDERATIONS ON FERTILIZING COTTON

**232. Draft of cotton on soil fertility.** Table X showed that in certain experiments the seed and lint together contained about half the total nitrogen and phosphoric acid but only a quarter of the potash found in the entire plant. The composition of a plant or of the part removed from the

soil is not a guide to the correct fertilization of that plant; yet it is well to know that the lint and seed together in a crop of 300 pounds of lint remove plant food which at ordinary prices would be worth in commercial fertilizers \$6 to \$10. Of this amount, the fertilizer constituents in the lint alone are worth only about 25 cents. Indeed, no other ordinary crop makes such slight demands on fertility as does the cotton fiber. If the seed and all other parts of the plant except the lint were returned to the soil, there would be no reductions in fertility except those due to extraneous influences, such as surface washing, loss of vegetable matter through clean cultivation, and loss of nitrates from the soil in the drainage water.

The seed and lint together, in the case of a crop of 300 pounds of lint, make a draft on soil fertility that is about the same as would be removed by the grain alone in a crop of 25 bushels of corn or of 35 bushels of oats.

**233. Amounts of fertilizer required to take the place of plant food removed by lint and seed.** Three hundred pounds of cottonseed meal and twenty-seven pounds of kainit will furnish all the fertilizer constituents removed from the soil by a crop of 300 pounds of lint with its accompanying seed; this quantity of cottonseed meal would supply not only the nitrogen, but all of the removed phosphoric acid. If the nitrogen were drawn wholly from the decay of leguminous plants and no cottonseed meal were applied, 51 pounds of acid phosphate, containing 14 per cent of available phosphoric acid, would supply all the phosphoric acid removed in a crop of seed and lint of the size indicated.

In fact, such figures give no idea of the amounts and kinds of fertilizer actually found to be advantageous for the cotton plant. For example, in practice the usual amount of acid phosphate is at least 120 to 200 pounds to the acre,

which supplies several times the amount of phosphoric acid removed by seed and lint in a crop yielding 300 pounds of lint. The necessity for applying much larger amounts of phosphoric acid than are apparently required by the composition of the cotton plant is largely due to the fact that a large proportion of the phosphoric acid is converted in the soil into compounds that are not promptly available.

Means of determining the fertilizer required by cotton on different soils are discussed in succeeding paragraphs.

**234. Phosphoric acid.** There are no indications either from the appearance of the soil or the plant as to whether phosphoric acid is needed. However, in regions where the use of commercial fertilizers for cotton is general, experiments and experience have indicated that the need for the application of phosphates is almost universal. Usually a fertilizer for cotton should contain more acid phosphate than any other single constituent.

**235. Potash.** In determining the probable need of cotton for potash, note should be made of the proportion of clay or silt compared with that of sand. Clay and silt are frequently formed from materials rich in potash; hence, the more clay or silt the soil contains, the less, as a rule, is the need for potash.

Some clay soils, however, contain a large amount of potash, but in an unavailable form. In this case the potash can often be made available by improved preparation and cultivation and by the addition of vegetable matter. The sandier the soil and subsoil, the greater is the need for potash. Even on sandy lands this fertilizer may not be needed in any considerable amount unless cotton rust commonly occurs on such soil.

**236. Nitrogen.** The proper proportion of nitrogenous fertilizer to acid phosphate in a fertilizer formula for cotton

depends more on the recent cropping and manuring of the field than on the character of the rocks from which the soil has been derived. One can usually decide whether nitrogen is needed by considering the following facts:

(1) Small stalks (if not due to climatic influences, poor cultivation, or the like) are usually an indication that nitrogen is needed.

(2) Excessive stalk, or "weed" growth of cotton, is an indication that nitrogen can be dispensed with wholly or partially.

(3) The fresher the land, the less the need for nitrogen.

(4) Phosphate hastens maturity and may make more severe the injury from cotton rust.

(5) A luxuriant growth of cowpeas or of any other legume just preceding cotton usually dispenses with the necessity for nitrogen in the fertilizer; so does a recent heavy dressing of stable manure.

However, the only positive means of determining the exact fertilizer requirement of any soil is by making on it an experiment with fertilizers.

**237. Effects of commercial fertilizers on the soil.** Commercial fertilizers are, on the whole, profitable, in spite of many misfits between soil, crop, and fertilizer. Indeed, in a large part of the Cotton Belt they are indispensable. The profits from their use will increase with a more general knowledge of agricultural principles. Commercial fertilizers occasionally have been charged with being largely responsible for the impoverished conditions of the cotton fields and the scant profits of the cotton grower. This is not correct. They do not in themselves exhaust the soil. Reliance on fertilizers alone may cause a farmer to keep his land too long in cotton, instead of letting cotton alternate with soil-improving crops, such as cowpeas. The exhaustion of the

fertility of the cotton fields is due chiefly to leaching, washing, and loss of vegetable matter as the result of continuous clean cultivation.

For the scant profits too often secured in the culture of cotton, the chief causes are impoverished soil, purchased



*Courtesy International Harvester Co.*

Fig. 108. — Acid soils may greatly increase in production when lime is used  
The view shows unlimed section between limed areas.

supplies, unintelligent use of fertilizers, scarcity of capital, deficiency of labor-saving machinery, unsatisfactory labor conditions, and the failure to apply the principles underlying a rational system of farming. To these has been added in recent decades the intolerable tax collected by

the cotton-boll weevil. Any financial loss in connection with fertilizers should be charged not to their use, but to their abuse.

**238. Advantages of the home-mixing of fertilizers.** Factory-mixed fertilizers or ammoniated guanos are in general use among cotton growers. One of the most widely used of these ready-mixed guanos contains about 10 per cent of available phosphoric acid, 1.65 per cent of nitrogen (equal to 2 per cent of ammonia), and 2 per cent of potash. This is spoken of as a 10-2-2 guano. If the farmer decides to buy the separate materials and do his own proportioning and mixing, he often purchases tankage, acid phosphate, and kainit. If he wishes to make a more concentrated fertilizer, that is, one of higher grade, he may buy the nitrogen in the form of nitrate of soda or sulfate of ammonia, and the potash in the form of muriate or sulfate of potash. Those farmers who understand how to mix fertilizers find that it is much more economical to do so than to buy the average ready-mixed guano. The mixture made at home usually costs several dollars less a ton than a factory-mixed fertilizer supplying the same amount of plant food and permits the farmer to suit the fertilizer to the particular soil or crop to which each lot is to be applied.

**239. Amounts of increase from commercial fertilizers.** The results of several hundred fertilizer experiments made on a great variety of soils in Alabama led to the conclusion that, as an average, each ton of home-mixed high-grade fertilizer *adapted to the soil* should afford an increase of about 1500 pounds of seed cotton, or one bale increase per ton of fertilizer. This was the result before the days of the boll weevil. Since its coming the use of fertilizers has become more imperative, though apparently giving a slightly smaller increase.

**240. Advantages of high-grade fertilizers.** The true test in choosing between two fertilizers consists in calculating which one affords a pound of nitrogen, potash, and available phosphoric acid at the lower price. High-grade fertilizers are usually more economical.

**241. Quantity of fertilizer to an acre.** Experiments in several states have shown that before the coming of the



*Courtesy H. G. Hastings Co.*

**Fig. 109. — A cotton field in Georgia**

boll weevil an application of 400 to 600 pounds to the acre of a fertilizer adapted to the soil afforded a larger profit to the acre than smaller amounts.

At the Georgia Experiment Station a complete fertilizer was used at the rate of 400, 800, and 1200 pounds an acre.

Each increase made a decided and profitable increase in the yield. However, the smallest lot returned much the highest percentage of profit on the investment; the 800 pounds paid a higher dividend than the largest amount. This illustrates the usual rule, which is that the percentage of profit on the investment in fertilizers decreases as the amount of fertilizer increases; but that the *profit an acre* is usually greater with the larger amounts, up to a certain point, which is often above 600 pounds an acre.

Moderate to large applications pay best when the season is favorable, but they involve the risk of loss should climatic conditions be extremely unfavorable or should boll weevils be especially destructive. To render as safe as possible heavy or intensive fertilization, the soils on which it is employed should be in good mechanical condition, especially as regards drainage and power to retain sufficient moisture during drought. This latter condition may usually be brought about by a rotation that affords an abundance of vegetable matter and by judicious preparation and cultivation.

### NITROGENOUS FERTILIZERS

**242. Nitrogen produced on the farm.** The cheapest sources of nitrogen are barnyard manure and the leguminous or soil-improving plants, such as cowpeas, velvet beans, hairy vetch, and (when pastured by hogs) peanuts. Manure may pay even better for hay and other forage crops than for cotton. Cottonseed is too high-priced in most localities for use as fertilizer.

**243. Cotton seed *versus* cottonseed meal.** Most tests show practical equality for a pound of nitrogen in cottonseed meal and in crushed or rotted cotton seed. To furnish

equal amounts of nitrogen requires the following amounts of each:

TABLE XI. COMPOSITION OF COTTON SEED AND COTTON-SEED MEAL

	NITRO- GEN (Pounds)	PHOS- PHORIC ACID (Pounds)	POTASH (Pounds)
2000 pounds of cotton seed contain . . . . .	62.6	25.4	23.4
963 pounds of <i>high-grade</i> cottonseed meal (6½ per cent nitrogen) contain . . . . .	62.6	26.5	16.3

The average of a number of experiments on many soils in Alabama showed that, as a fertilizer for cotton, one pound of *high-grade* cottonseed meal was equal the first year to two and one-sixteenth pounds of crushed cotton seed. Later experiments in Alabama and Georgia make a still more favorable showing for the meal. It seems safe to conclude that on most soils half a ton of *high-grade* cottonseed meal is about equal as fertilizer to a ton of cotton seed.

The oil is without value as a fertilizer, and the hulls contain but little plant food. Therefore, the most complete value of cotton seed is obtained when the oil mill extracts the oil.

It has been shown that the meal and hulls from one ton of cotton seed is at least as effective a fertilizer as the entire seed. Hence, the farmer who can exchange one ton of his seed for the meal and hulls contained in it loses nothing in fertilizing value. When he can obtain 1200 pounds or more of meal and no hulls for one ton of seed, he usually makes a nearly equal exchange, if the cost of hauling is disregarded. He should usually obtain in ex-

change for a ton of cotton seed, considering only the fertilizing value, as many pounds of meal in excess of 1200 as will pay for hauling both ways and afford whatever profit he may be able to obtain.

**244. Other forms of nitrogen.** The farmer should buy either nitrate of soda, cottonseed meal, dried blood, tankage, or other form of nitrogen, choosing that one in which a pound of nitrogen costs least. Most experiments fail to show any notable difference in the value of a pound of nitrogen from these different sources.

**245. General need of cotton soils for nitrogen.** Nitrogenous fertilizer is highly beneficial to cotton on a large proportion of the cultivated area of every region where the soils have become poor. Apparently it is almost universally needed on uplands in such regions except on (1) new grounds and on (2) soils containing considerable vegetable matter, as the result of proper rotation with cowpeas or other humus-forming crops.

**246. Cost of a pound of nitrogen.** A pound of nitrogen in commercial fertilizers usually costs 15 to 25 cents. To learn the average cost each year, inquiry should be made of the State Commissioner of Agriculture at the capital city of the state.

**247. A rational system of fertilization with nitrogen.** Considering permanent effect, as well as influence on the crop immediately following, the cowpea and other leguminous plants must be ranked as a cheaper source of nitrogen than is any nitrogenous material which may be bought as commercial fertilizers. The aim of the cotton farmer should be to grow such areas of legumes as will enable him to dispense with the purchase of much nitrogenous fertilizer for cotton, using the funds saved to purchase increased amounts of phosphates or other necessary non-nitrogenous fertilizers. The

money that would have been necessary to purchase one pound of nitrogen will buy about three pounds of phosphoric acid or of potash, which larger purchases of phosphate and potash will enable the farmer to grow heavier crops of legumes; and heavier crops of legumes trap larger amounts of otherwise unavailable atmospheric nitrogen and result in further soil enrichment and larger yields of cotton.

### PHOSPHATIC FERTILIZERS

**248. Different kinds of phosphate.** While there are a number of forms in which the farmer may obtain phosphoric acid, the one that is most generally employed in the Cotton Belt is *acid phosphate*. This usually contains 16 per cent of available phosphoric acid. Acid phosphate is manufactured by adding sulfuric acid to the finely ground phosphate rock, or raw phosphate. The sulfuric acid is employed in order to make the phosphoric acid promptly available to plants by making soluble the original phosphate rock. Acid phosphate usually contains only about half as large a percentage of phosphoric acid as the raw phosphate from which it was made. However, nearly all of the phosphoric acid in acid phosphate is in a soluble or available condition.

The sulfur contained in acid phosphate has sometimes proved helpful to certain leguminous plants, and cotton also may be found to benefit by it on certain soils.

*Raw phosphate* consists of the finely ground phosphate rock without treatment with any acid. Among the names given to it are crude phosphate, ground phosphate rock, and floats. It usually contains from 26 to 30 per cent of total phosphoric acid. All of this is insoluble, and hence not in a form to be immediately used by the roots of plants.

Ground phosphate rock contains about twice as much total phosphoric acid as does acid phosphate.

Another source of phosphoric acid is basic or slag phosphate; this is close to acid phosphate in availability, and in addition it has a slight neutralizing effect on soil acidity. Still another source of phosphoric acid is ground bone, which is not extensively used by cotton growers.

The cost of available phosphoric acid in commercial fertilizers usually ranges around 6 or 7 cents a pound.

**249. Effects of different phosphates on cotton.** Repeated experiments in many states have shown that cotton can make some use of raw phosphate, but that acid phosphate usually is much more effective. However, experiments have also shown that the raw phosphate becomes more quickly available if it is mixed with large amounts of rotting vegetable matter.

The use of raw phosphate for cotton probably should be restricted to cases in which it can be thus used with manure or leaf mold or to soils on which a large amount of vegetable matter is being plowed under. Even in the latter case acid phosphate is usually the more profitable the first year. Moreover, acid phosphate is more effective in hastening maturity, an important advantage under boll-weevil conditions.

It is generally believed that the residual effects, that is, the effects subsequent to the year in which it is applied, are greater with raw than with acid phosphate; but the difference in residual effect has seldom proved sufficient to overcome the usual greater efficiency of acid phosphate in the year in which it is applied.

**250. General need of cotton soils for phosphate.** The need for phosphate as a fertilizer for cotton is apparently almost universal on poor land east of the Mississippi River.

Phosphate is also often needed on the rolling cotton lands west of the Mississippi that have sandy and loamy soils.

The principal phosphate mines are in South Carolina, Tennessee, and Florida. Some authorities estimate that unless new phosphate mines are developed or the export of phosphate to foreign countries decreases, the supply of high-grade phosphate rock will be exhausted before the close of the present century. This is one of the considerations that should lead farmers to utilize on the farm the substances rich in phosphoric acid. Richest of these are the bones of animals. Cotton seed, and all other seeds, contain considerable phosphoric acid, which is largely retained on the farm when these seeds are there fed to live stock.

### POTASH FERTILIZERS

**251. Extent of the need for potash.** Potash is more abundant in Southern soils than is phosphoric acid or nitrogen. Therefore, most crops make less demand for potash in the fertilizer. Cotton agrees with most other crops in ability to thrive on many soils without artificial supplies of potash, yet on the sandier soils, especially of the Coastal Plain, cotton generally makes more profitable response to potash than does any other widely grown crop.

**252. Potash as a means of checking cotton rust.** On soils very liable to severe injury by attacks of cotton rust the use of potash is recommended; for on such soils potash, ordinarily in the form of kainit, has conspicuously decreased the amount of rust and greatly increased the yields. Rust occurs most frequently on poor sandy soils. Hence, on these potash is needed more frequently than elsewhere for cotton.

In several hundred local tests conducted by the Alabama

Experiment Station, 100 pounds of kainit to an acre have been highly effective in restraining cotton rust, apparently about as effective as 200 pounds.

In one test 60 pounds of kainit effected a noticeable decrease in the injury from this disease. Apparently it is safer to use at least 80 pounds to the acre where the purpose is to combat rust.

In these experiments two facts relative to kainit and cotton rust are noticeable: (1) the usual favorable effect of kainit in checking rust and (2) its occasional failure on some soils and in some seasons to reduce the injury resulting from this disease. Just how potash decreases rust is not well understood. It enables the cotton plant to remain green and thrifty through periods of unfavorable weather. Probably it reduces the amount of water necessary to keep the plant in health, judging by the fact that potash has been found to reduce the amount of water transpired by the leaves of the corn plant. Potash in the fertilizer usually causes the later retention in the autumn of the leaves of the cotton plant.

**253. Kainit and muriate and sulfate of potash.** In experiments in Alabama, a pound of potash in the form of muriate was as effective in checking rust as when an equal amount was applied in the form of kainit. It is slightly less convenient to apply muriate of potash; for as this is four times as strong as kainit, it is advisable to use only 25 to 50 pounds of the muriate to the acre, which small amount necessitates extreme care in pulverizing and distributing evenly. Aside from this slight consideration of convenience, the farmer should buy that one of these materials in which a pound of potash delivered at his farm costs him less. Where the freight rate and cost of hauling is high, the muriate will be the cheaper source of potash;

near seaport cities, or where freight rates are low, kainit may be the cheaper form.

Kainit usually contains about 12 per cent of potash and muriate four times this amount. Another source of this plant food is sulfate of potash, in which a pound of potash usually costs a little more than in kainit or muriate. The supply of potash salts comes from mines in Germany and adjacent parts of France.

#### MISCELLANEOUS FERTILIZERS AND EFFECTS OF FERTILIZERS

**254. Lime** has shown very slight effect as a fertilizer for cotton in several tests in South Carolina and at Auburn, Alabama. At any rate, cotton is not conspicuously a lime-loving plant, like clover, wheat, blue grass, and the like. Neither is cotton averse to lime, as shown by its successful growth on numerous limestone soils.

**255. Composts.** As the word "compost" is used by cotton planters, it usually refers to a mixture of stable manure, cotton seed, and phosphate, which, after being brought together, are allowed to ferment four to eight weeks. Other coarse materials, and also other chemical fertilizers, often enter into composts. The theory underlying the making of composts is that during the fermentation, materials previously insoluble are decomposed and converted into a soluble condition.

Taken as a whole, four experiments at the Alabama Experiment Station offer no argument in favor of composting such materials as cotton seed, fine stable manure, cotton-seed meal, and acid phosphate. Nor do the experiments along this line made at other Experiment Stations sustain the claim that these materials can usually be composted profitably for cotton when the price of this staple is low and labor

expensive. With high-priced cotton and cheap labor otherwise unemployed in winter, composting may be profitable.

**256. Effects of fertilizers on maturity.** Cotton grown on poor land is late in maturing, unless the process is hastened by the loss of leaves from rust, or by the premature death of the plants.

Acid phosphate decidedly hastens the maturity of cotton. Its use enables the farmer to obtain at the first picking, or at the first and second pickings, a larger proportion of the total crop of cotton than by the employment of any other single fertilizer. Other forms of phosphoric acid, including raw phosphate and basic slag, and raw phosphate when used in connection with only moderate amounts of stable manure, have also been found to hasten maturity. At the Texas Experiment Station (*Bulletin*, No. 75) the plants fertilized with acid phosphate were 18 inches high when the plants on the unfertilized area and on the plots fertilized with nitrogen or potash alone were less than half that height; at the time when the phosphate plants bore eight to sixteen squares each, the other plants averaged only about four squares.

Nitrogen in commercial fertilizers in small or medium amounts somewhat favors early maturity. When a nitrogenous fertilizer is combined with acid phosphate, the highest degree of earliness is secured. On the other hand, maturing is retarded if the amount of nitrogen is excessive or if a nitrogenous fertilizer is applied very late. It is a common observation that stable manure makes cotton late in opening. This can be overcome by carefully avoiding the use of excessive amounts and by supplementing the manure with any form of phosphate.

The use of potash usually causes the crop to retain its leaves and to continue growing late into the fall. Hence, potash does not promote early maturity, but in judicious

proportions in a complete fertilizer it does not exercise an injurious retarding effect.

In North Carolina, C. B. Williams found that slaked lime hastened maturity when used in connection with a complete fertilizer.

Commercial fertilizers, judiciously employed, constitute one of the most effective means of insuring the early opening of cotton and thus of securing a crop before boll weevils become so numerous as to destroy all young forms.

By hastening the maturing of the cotton plant, commercial fertilizers have enabled farmers to grow cotton in higher latitude and in higher altitudes than was possible before their use became common.

**257. Effects of fertilizers on quality.** In Egypt, where a cotton of very long fine staple is produced, attention has been directed to the effects of fertilizers on the quality of lint. Observations on cotton, growing in the rich soils of that country, indicate that heavy applications of fresh or unfermented barnyard manure, or other fertilizers promoting a very rank growth late into the fall, injure the quality of lint; while phosphates, which hasten maturity, improve the staple. Partly on account of the more prompt action of nitrate of soda as compared with sulfate of ammonia or other nitrogenous chemicals, the former is there given preference as a supplement to an application of manure.

### LABORATORY EXERCISES

(1) Assuming that nitrogen is worth 20 cents a pound, available phosphoric acid 7 cents, and potash 7 cents, calculate the commercial value of the plant food in a ton of fertilizer of the following composition:

- (a) 10 per cent available phosphoric acid, 2 per cent nitrogen, and 2 per cent potash;
- (b) 10 per cent available phosphoric acid, 3 per cent nitrogen, and 3 per cent potash;

(c) 5 per cent available phosphoric acid, 4 per cent nitrogen, and 5 per cent potash.

(2) Calculate the percentage of nitrogen, phosphoric acid, and potash in a mixture of:

300 pounds nitrate of soda containing 14 per cent of nitrogen;

500 pounds kainit, containing 12 per cent of potash; and

1200 pounds of acid phosphate, containing 16 per cent of available phosphoric acid.

(3) Calculate how many pounds of each of the three fertilizers just mentioned would be required to make a mixture containing the same amounts and kinds of plant food as one ton of guano analyzing 10 per cent available phosphoric acid, 1.8 per cent nitrogen, and 2 per cent potash.

(4) Calculate how many pounds of the same kind of phosphate and kainit as in (2) and of cottonseed meal containing 2.8 per cent of available phosphoric acid, 5.5 per cent of nitrogen, and 1.8 per cent of potash would be required to contain the same kinds and amounts of plant foods as one ton of guano analyzing 10 per cent available phosphoric acid, 3 per cent nitrogen, and 3 per cent potash.

### ADVANCED TOPIC

A study of results of fertilizer experiments with cotton by Experiment Stations of states having soils resembling those of your state.

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## CHAPTER XVI

### COTTON CULTIVATION

Most of the routine practices in making a seed bed for cotton, planting the seed, and cultivating the crop are based on age-old custom. Some of these details are merely traditional; others embody the experience of the best farmers and the results of modern research. Hence he who would be most successful in growing cotton under the essentially new conditions of increasingly expensive labor and of boll-weevil infestation must analyze each step in the procedure of preparation and cultivation with a view to making any modification required by his changed environment.

**258. Methods of plowing.** Some fields intended for cotton receive only one plowing before the seed are planted. This usually consists in forming ridges or beds by throwing together four or more furrow slices. More thorough preparation is given by first plowing the land level or flush and afterwards forming the beds by a subsequent plowing; the beds may be formed with minimum labor by a disk cultivator or by a double moldboard plow (Fig. 110). This double preparation seems most important for stiff soils and for uncultivated, stubble, or weedy land.

**259. Time of plowing or breaking.** February and March are the months in which the greater part of the plowing of cotton land is done. The time of plowing is largely a matter of convenience. The general rule should be that the larger the proportion of clay in the soil, the earlier may plowing be done to advantage, provided the surface is freshened

later. The larger the amount of trash to be buried and rotted, the earlier should be the date of plowing. Any coarse stalks should be chopped first with a stalk cutter. Some farmers begin plowing for cotton in December or even in November. This permits freezes to aid in pulverizing the soil, and in killing some kinds of cotton insects that spend the winter in the ground.



*Courtesy International Harvester Co.*

**Fig. 110. — A middle-breaker plow**

**Note that it has two moldboards.**

Early plowing may cause clay land to become too compact before the time for planting. In this case it is desirable, shortly before planting, either to replot the land or to loosen the surface with a disk harrow. Too early plowing of sandy land increases the loss due to the leaching out of plant food in the water that drains through the soil. Hence, sandy land, as a rule, is not plowed in the fall. However, it is good practice to plow any soils except the sandiest in the fall, provided some winter-growing crop, such as the small grains, clovers, or vetches, are sown. The roots of the growing plants largely prevent leaching by appropriat-

ing the plant food that becomes available as the vegetable matter decays. These green crops can be plowed under in the late winter or early spring, or can be grazed or otherwise utilized. Plowed soil should be kept covered during winter with growing plants. Fields covered with cowpeas or other dead leguminous plants should not be plowed very early, since early fall plowing would induce rotting and leaching before the cotton plants would be ready to utilize the nitrogen made available by the decay of the legumes.

**260. Depth of plowing.** Some cotton fields are plowed only three to four inches deep. It is generally advisable to plow deeper than this, so as to afford a larger amount of available soil moisture for the benefit of the plants in periods of dry weather and to increase the feeding area for the roots. However, extreme depth, as well as extreme shallowness, is to be avoided. Plowing too deep may bring to the surface much of the subsoil, where, for a year or two, it remains infertile and subject to baking or clod forming. A depth of six to eight inches may be regarded as unusually good preparation; this depth should be attained only gradually, that is, by plowing each year only about an inch deeper than the year before. By a gradual and judicious increase in depth, a few farmers have advantageously stirred their soil to even a greater depth than six to eight inches. For very deep plowing the disk plow is a favorite implement.

When plowing is early or several months before the time of planting the seed, the depth may well be greater than in late plowing. This is because the earlier plowing permits the upturned subsoil to be improved by the action of freezes and of the air, and because the deeper layer of stirred soil requires a longer time to settle to that degree of compactness most favorable to the germination of seeds and the growth of roots.

Even when deep preparation fails to increase the yield the first year, an increase is likely to result in succeeding years. The aim of the cotton grower should be gradually to deepen the layer of plowed soil.

Subsoiling has had various results, often inadequate to cover the increased cost. The same considerations apply in subsoiling for cotton as for corn (139).

**261. Planting cotton on a level.** Practically all the cotton of the United States is planted on ridges, or beds. However, a few farmers, on well-drained sandy soil, plant late cotton on land that is not bedded, but merely "flushed," or "plowed broadcast." This requires very shallow planting and very careful early cultivation to prevent covering the plants. The object in planting on a level is to enable the plants better to endure drought.

A method that is generally an improvement on the last named consists in forming low beds; before being planted they are pulled down almost level by being harrowed or dragged whenever a crust forms or whenever young weeds appear.

**262. Distribution of fertilizers.** The rows having been marked off, usually with a shovel plow, the fertilizer (if any is to be used) is drilled in this furrow. It is most conveniently put in place by means of a one-horse fertilizer distributor, which also draws earth over the fertilizer. Immediately a "list" is formed. The bed may be completed at once or, more frequently, not until the entire area intended for cotton has been fertilized thus and listed. On some farms the fertilizer is distributed by hand either through a "guano horn" or without this inexpensive device.

**263. Time of planting.** The usual date for the beginning of cotton planting is two to three weeks after the average date of the last killing frost in that locality. Planting

begins in March near the Gulf of Mexico; about April 1 in the central part of the Gulf states; and in the extreme northern part of the Cotton Belt it may be delayed until May. In the central part of the Cotton Belt most of the crop is planted before May. Extremely early planting increases the risk of injury by frost in spring and the labor of cultivation. Rather early planting is advisable as one step in inducing fruiting before boll weevils become numerous.

**264. Cotton planters; delinting seed.** There are numerous forms of planters for cotton. Most of them plant a single row at a time, opening the furrow, dropping the seed, and covering the seed at one trip (Fig. 111). Probably the most important features about a planter are: (1) provision for constantly agitating the mass of seed, so that the feed may be uniform and (2) provision for rolling or otherwise pressing the soil around the seed.

If the earth above the seed is rolled, or otherwise compacted, the depth of planting may be as shallow as one inch. The usual depth is from one to two inches.

*Delinting.* Some planters drop the seed at regular intervals rather than in a continuous drill. Such planters may require that the seed be first treated by some method that will serve to lay the fuzz and enable the individual seeds to be separated from the mass. This may be effected by reginning the seed, thus removing much of the fuzz. Another method consists in adding a little thin flour paste to the dry cotton seed while they are being shaken in a revolving barrel (230).

A still more effective method, for small-scale planting, consists in coating the seed with full-strength commercial sulfuric acid. Into a lot of seed, continuously stirred, is poured a small stream of acid. This treatment may con-

tinue for ten or more minutes, or until the fuzz is charred. Then the sulfuric acid must be thoroughly washed off the seed, so as to prevent loss of germinating power. It is the diluted rather than the concentrated sulfuric acid



*Courtesy International Harvester Co.*

Fig. 111. — A cotton planter with runner or shoe opener

that is able to penetrate the seed coats and endanger germination.

In 1922 a process was developed by the U. S. Department of Agriculture for more conveniently removing the fuzz by spraying hydrochloric acid on cotton seed.

The most common method of preparing the seed for very thin planting consists in "rolling the seed." This is done by dampening the seed, placing them in a barrel fitted with a frame and crank in such a way that it may

be revolved; then dry ashes or dust is added, and the barrel revolved, thus causing the ashes or dust to coat each seed and temporarily to paste down the fuzz.

These treatments, and especially the use of sulfuric acid, hasten germination by permitting closer contact of the seed coat with moist soil. Thus a few days may be gained in the race with the boll weevil.

**265. Quantity of seed.** A bushel of cotton seed usually contains between 120,000 and 150,000 seeds, or enough, if each one developed into a mature plant, to suffice for fully fifteen acres. However, it is customary to plant 1 to  $1\frac{1}{2}$  bushels of seed to the acre. An ideal planter that places the seed in a narrow drill or in hills requires less; and still less is necessary when planting is done by dropping the seed by hand in separate hills.

On stiff land, it is regarded as advantageous to have a thick stand of plants, so that the combined strength of the young plants may be exerted to break through the surface crust, which might be too strong for a single plantlet. On the other hand, the presence of only one seed in a place greatly reduces the labor of chopping or thinning cotton. Thick stands favored under boll-weevil conditions call for thick planting.

**266. Broadcast tillage.** One change which should be made in cotton culture is the introduction of broadcast tillage; that is, of cultivation or tillage across the rows by means of weeders or of light spike-tooth, adjustable harrows. This kind of tillage permits a larger area to be covered in a day's work of man and team than does any other kind of cultivation. It has the double object of breaking the surface crust before this has become very thick and hard, and of destroying weeds and grass while they are extremely small or merely sprouting. One horse drawing

a weeder, or a double team drawing a light spike-tooth harrow, may cultivate ten or more acres in a day.

As soon as a crust begins to form, there is need for the use of a weeder or light harrow at the following stages in the cultivation of cotton:

(1) A few days or weeks before planting, in order to break the crust.

(2) Following a rain occurring soon after planting, which otherwise would leave too dense a crust to be easily broken by the young plants.

(3) Between the time when the young plants first take on their green color and the time when chopping or thinning is done.

However, it may be impracticable to use as in (3) either weeder or harrow on stony land, on a field where there is much trash, and where the stand is thin or very irregular.

The judicious use of the weeder or light harrow just before chopping cotton permits this operation to be postponed longer and to be effected with less labor.

**267. First tillage by separate rows.** As soon as practicable after all the young plants have appeared above ground and have taken on a green color, the first tillage is given with some form of cultivator (Fig. 112).

Since one main purpose of this first operation is to prepare for the more expensive work of chopping, any implement now used must run very close to the line of young plants without throwing much earth toward them. The implement generally used in this operation — which is usually called scraping, or barring off — is either any ordinary cultivating tool supplied with a fender to prevent the rolling of too much soil on the tiny plant or a moldboard, or turnplow, with the bar side toward the line of plants, so as to throw the soil away from the row. The turnplow thus

used has the disadvantage of leaving the young plants on narrow high ridges, which quickly dry out. However, its use may be necessary where weeds and grass have made so much growth as to require complete overturning and burying.

Labor is saved by barring off both sides of a row at the same time, as is sometimes done with a two-horse cultivator equipped with disks or other devices for throwing the soil from the young plants.

### 268. Chopping or thinning.

As soon as possible after the operation of scraping, or barring off, the young plants should be thinned by means of a hoe. This first hoeing is called *chopping*. Usually either one or two plants are left at the desired distance apart. Much subsequent

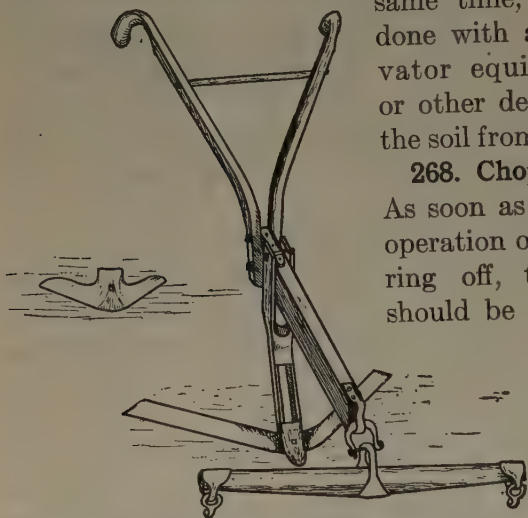


Fig. 112. — A plowstock, scrape, and sweep, extensively used in cultivating cotton

hoe work is saved if, at the time of chopping, the plants can be safely thinned to the final number. However, it may be wise to leave more plants in a place than will finally remain, if chopping is done when the plants are extremely small, or if many of them are expected to die as the result of disease or of unfavorable weather.

**269. Second cultivation, or "siding."** The objects in *siding* cotton are as follows:

- (1) To throw close about the plant, for its firmer sup-

port, earth that may have been removed from it in the first cultivation or in hoeing.

(2) To destroy weeds.

(3) To form a mulch that may aid in retaining the moisture in the soil layer just below it and be unfavorable, because of its dryness, for the prompt germination of small weed seeds.

Since one purpose is to throw a little earth towards the plants, the scrape or sweep now employed may be wider than that used at the first cultivation. To keep the small plants from being covered, it may still be necessary to use a fender attached to the stock or cultivator.

This second tillage is done by running the cultivating implement close on both sides of each row of plants. Human labor is economized by employing in this and subsequent tillage a two-horse cultivator.

Siding should sometimes be done as soon as practicable after chopping, but in order to give time for grass to be smothered by the earth thrown on it in "barring off," it may be delayed.

**270. Third tillage, or cleaning middles.** If the siding just described has been performed with only two scrape furrows to a row, there is usually left a low ridge of soil, called a balk, or *middle*, halfway between each two lines of plants. If this strip becomes compact or weedy, the next step is to cultivate it. This is usually done by a single furrow of a rather large sweep or scrape (Fig. 112), which splits the middle, lapping part of it on each of the adjacent rows. When a double cultivator is employed, it cultivates the plants on both sides and throws out the middles at the same time. Even when a single scrape is used in siding, farmers often prefer to throw out the middle immediately.

**271. Subsequent tillage.** The operation of siding is repeated as often as necessary to destroy all young weeds and grass and to prevent the formation after each rain of a crust on the soil. Likewise, the middles are cleaned or thrown out as often as necessary for the same purpose. The larger the plant becomes, the wider, as a rule, are the scrapes or sweeps employed.

**272. Subsequent hoeing.** The hoeings subsequent to chopping are necessary only when vegetation grows along the line of plants in spite of the earth thrown upon the young weeds in siding. Hoeing is, next to picking, the most expensive operation in cotton culture; hence, as far as practicable, the horse implements should be made to lessen the necessity of hoeing.

**273. Amount and frequency of tilling.** There can be no fixed rule as to how often cotton should be cultivated. The general rule is to cultivate it whenever tiny weeds appear and before the formation of a crust following each rain. Four plowings may be considered the minimum and six or more are often advisable. The total number of furrows to a row required in good tillage is usually between twelve and sixteen. In addition to this, two or more hoeings are usually given.

**274. Late tillage.** Practice varies greatly as to the stage in the life of the cotton plant when cultivation should cease. In most parts of the Cotton Belt, tillage is continued through July and sometimes into August. The general rule is that cotton plants that are making less than a normal growth of limbs and foliage should be cultivated late, while plants of large size may be laid by earlier, so as to check the growth of stalk.

After cotton has received what has been planned to be the last tilling, rains sometimes occur within a few days,

destroying the soil mulch made by the last cultivation and starting a new growth of weeds. In this case it is usually advisable to give an additional late cultivation.

**275. Depth of cultivation.** The same principle applies here as in the tillage of any other crop. At the first cultivation the depth may well be shallow, medium or deep, as the judgment of the farmer dictates; but in the subsequent tillings the depth should be shallow, that is, just deep enough to destroy vegetation and to form a soil mulch.

Usually a depth of  $1\frac{1}{2}$  to 2 inches meets these requirements. The finer the soil particles forming the mulch, that is, the more complete the pulverization effected by the tilling implement, the less the thickness of soil mulch required to check evaporation. In recent years more stress has been laid on cultivation as a means of destroying weeds than in directly reducing surface evaporation.

**276. Sowing seed among growing cotton plants.** When it is desired to improve the soil by growing, during the cooler months, some soil-improving plant, such as crimson clover or hairy vetch, the time usually selected for sowing the seed is immediately after the first picking. By choosing this time, no cotton is knocked from the plants by the one-horse cultivator used in covering these seed. On some farms fall-sown oats are sowed among the growing cotton plants and covered as just indicated. To permit the use of harvesting machinery in the oats, the cotton plants, if large, are loosened in winter by means of a narrow plow, or by the use of a subsoil plow, and then pulled and removed.

**277. Distance between rows.** As a general rule the richer the land, the wider should be the rows.

This was a correct basis before the boll weevil came, and experimental evidence to date apparently points to no needed change in the distance between rows. This rule is

exactly the opposite of the practice in spacing Indian corn. The reason for making the rows farther apart on rich land is the fact that cotton is a branching or spreading plant, and hence on rich land requires much space for the outward growth of its long branches. On the other hand, corn has no branches and may be crowded as closely together as is permitted by the supply of plant food and of moisture, both of which are of course more abundant on rich land.

The usual distance between rows of cotton on upland, where a crop of one-half bale or less to the acre is expected, is  $3\frac{1}{2}$  feet. On highly fertilized upland, the distance may well be increased to 4 feet. On bottom land and other very rich land, even wider rows were occasionally employed before the coming of the boll weevil.

The wider the rows can be made without reducing the yield, the cheaper is the cost of cultivation, since work with cultivators is cheaper than work along the rows with the hoe.

**278. Distance between plants in the row.** Before the arrival of the boll weevil it was sound practice to avoid extremely close planting and on rich land to give fairly liberal distance between the plants in the row. The presence of the boll weevil seems to make necessary a reversal of this rule. The tendency of recent experiments has been to show that in the presence of this pest a thick stand of plants in the row results in the production of the largest yields. This is doubtless because thick planting hastens maturity. However, it should be borne in mind that most of these tests were made on land of more than average fertility, or which received somewhat more than the average amount of fertilizer.

It seems that on rich land, or under highly favorable conditions, a plant every six or eight inches is none too close, and that even a thicker stand may be satisfactory. While additional experiments are needed to determine the

best spacing of cotton on poor land, it now seems advisable to give the plants there somewhat more space in the row than on rich land and yet to leave a thick stand.

**279. Planting in checks.** Experiments have usually resulted in reduced yields from checking cotton, where a single plant was left in each hill. However, on sandy river bottom land in Arkansas, W. E. Ayres found that checking cotton did not materially reduce the yield, provided two, three, or four plants were left in each hill.

### LABORATORY EXERCISES

The laboratory work to accompany this chapter should consist of participation in any of the operations connected with cotton culture that may be in progress at the time this subject is studied. In case this is not practicable, field observations on the results of such operations should be made by the student and presented to the instructor in the form of written descriptions or drawings.

### ADVANCED TOPICS

A. Field counts to determine the number of matured bolls formed by cotton plants growing at different distances in the row.

B. A detailed library study of the results of spacing experiments made under conditions of boll-weevil infestation.

C. A study of capillarity in the soil and the relative importance of (1) weed destruction and (2) the formation of a soil mulch.

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## CHAPTER XVII

### COTTON — HARVESTING AND MARKETING

Picking, ginning (removing the lint from the seed), baling, and compressing into very hard and compact bales for long-distance transportation are the different processes in the harvesting and marketing of cotton; and to these is here added a brief discussion of grades, qualities, and market classes.

**280. Picking and yields.** The picking of the crop is the most expensive operation connected with cotton culture. The price paid for this service varies greatly. Picking begins in August or early in September. The greater part of the crop is picked in the months of September, October, and November. •

A fair day's work for an experienced picker is 150 to 200 pounds of seed cotton; but very skillful pickers, under special incentives, and for a single day at a time, have picked more than double these quantities.

In picking, the principal aims are: (1) rapidity of work, (2) the inclusion of only the minimum amount of trash, and (3) completeness of work, so as not to leave in the bur an occasional lock or piece of a lock. In connection with the latter aim it should be borne in mind that it is sometimes more profitable to leave unpicked a lock of stained or diseased cotton than to include it with the main picking, since it would tend to lower the quality of the entire lot and to perpetuate disease if the seeds are used for planting.

When locks lying on the ground where they have been stained by dust or mud are included with the main picking of white cotton, the selling price of the whole is lowered. It may pay to harvest stained cotton separately or else to



*Courtesy International Harvester Co.*

**Fig. 113. — Picking cotton in Georgia**

**Note the use of oak baskets for handling the seed cotton.**

leave it unpicked. Cotton picked while wet, unless afterwards very thoroughly dried, makes a poor staple, which sells at a reduced price, because the fibers of damp cotton are broken in ginning.

The average acre yield in the United States in the first decade of the present century was about 200 pounds of lint, or two fifths of a bale to the acre. With the spread of the boll weevil to most parts of the Cotton Belt, the yield for

the first three years of the third decade was only about 132 pounds.

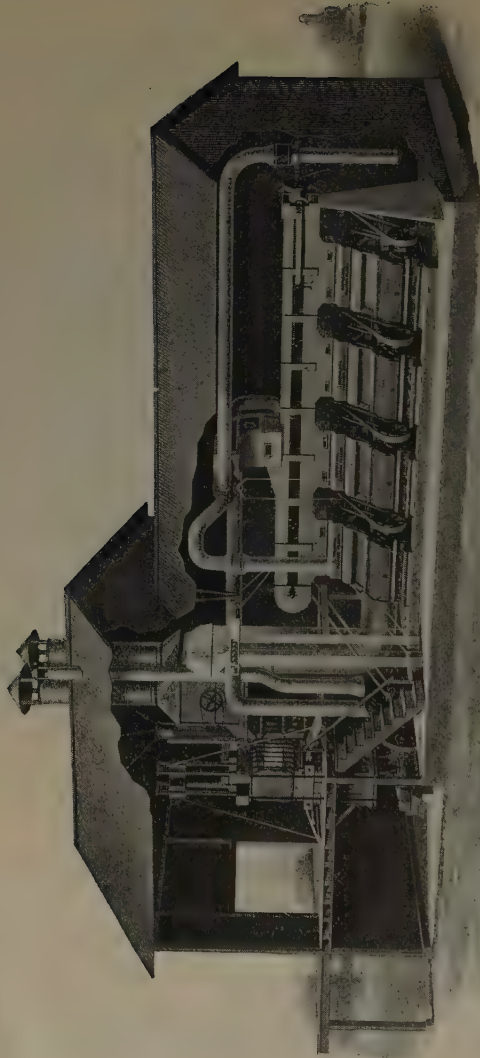
**281. Mechanical cotton pickers.** Many cotton pickers have been invented, few have been manufactured, and none has come into extensive use up to 1924. However, in the half decade before the World War and in the same period after it, several cotton-picking machines have demonstrated that they can pick large quantities, that they can harvest 80 to 90 per cent or more of the cotton open at the time of operation, and that they can pick without including very much more trash than is included by careless hand picking.

Many of these mechanical pickers are only partly automatic, and they require human brains and hands to guide the separate picking devices.

Some of these machines operate on the suction principle; the open end of a hose pipe is directed by the human hand close to each open boll, when the suction created by a revolving fan on the machine draws the seed cotton through a tube and into a hopper.

Other mechanical pickers entangle the seed cotton by means of innumerable sharp tack-like points embedded in narrow revolving belts, which are directed by human hands into contact with the open boll; the lint is instantly entangled and borne along the revolving belt to the hopper, where it is removed by brushes.

It seems safe to predict that the time will come when cotton-picking machines will harvest a part of the crop where the conditions for their work are most favorable, as on nearly level land, and where labor is scarce or expensive. The chief difficulty in the way of their rapid introduction is the high price at which it is now proposed to sell these mechanical pickers.



*Courtesy Continental Gin Co.*

**Fig. 114. — Section through a gin house**

**Note four gins on the right, with suction pipes for conveying cotton, and a press on the left.**

**282. Ginning.** After being picked, the seed cotton is hauled to the gin, which is usually a public ginnery, operated by steam power (Fig. 114). There suction pipes lift it from the wagon, and suitable devices carry it through a cleaner, and thence through the gin, which breaks the lint from the seeds by means of circular saws that revolve at a speed of about 400 to 500 revolutions a minute. A brush removes the lint from the saws and passes it to a condenser, which presses it into layers.

Cotton ginned when damp affords a poor sample because the gin cuts a considerable proportion of the fibers.



Fig. 115. — Cotton bales exposed to the weather

It is generally believed that a better grade or sample is afforded by storing the seed cotton for a few weeks than by ginning it soon after picking.

**283. Baling.** The fleecy staple is then conveyed to the press and compacted into rectangular (so-called “square”)

bales, which usually weigh about 500 pounds each, or about 14 pounds for each cubic foot.

The bales are covered with heavy coarse cloth or "bagging." One of the greatest wastes connected with the growing and marketing of cotton in the United States is the failure to use a sufficient amount of bagging and of a quality suitable to prevent the staining of the outer layers of the staple with mud and dust (Figs. 115, 116).

The amount of tare (or weight of bagging and ties) which the trade is supposed to allow is 30 pounds on a 500-pound

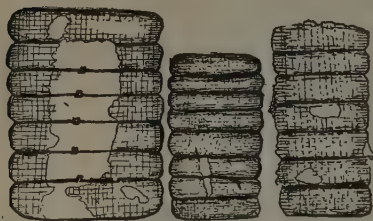


Fig. 116. — Side view of bales

On left, ordinary square bale; on right, ordinary compressed bale; between, bale from gin compress.

bale; but only on a few bales do the bagging and ties weigh this much, and these are penalized, or "docked"; the interest and influence of local buyers is in favor of a light or deficient covering. A general improvement in the amount and quality of covering of the bales of American cotton, which are now more

poorly protected than those from any other part of the world, would, in time, redound to the profit of both the farmer and the spinner.

The round bale, on the other hand, is usually covered very completely with cotton cloth, which affords satisfactory protection. Moreover, the round bale is dense and requires no further compression. However, for various reasons the round bale has not been able to come into general use in the face of opposition in the interest of compress men and manufacturers of square-bale presses. The round bale usually weighs about 250 pounds, or half as much as the square bale.

**284. The cotton gin.** There are two main types of gins, roller and saw gins. The former are used in ginning sea-island cotton, the naked seeds of which are easily separated by rollers from the lint. This general type of gin has been in use in India for centuries.

The saw gin, employed to gin short-staple cotton, is a modern machine, which has been second to no other agricultural invention in its effects on the world's wealth, commerce, and comfort. The saw gin has made possible the South's greatest industry — cotton culture — and has supplied with fleecy food the textile industries of all manufacturing nations. It was invented by Whitney and Holmes about 1792. Before that time a laborer with his fingers separated about one pound of lint cotton a day.

A single gin of average size accomplishes the work of about 4000 such laborers. Within one hundred years after its invention the saw gin made possible a four-hundred-fold increase in the cotton crop of the United States.

The saw gin is also used in ginning long-staple upland cotton; but to do this without injury to the staple, the usual speed of the saws should be greatly decreased.

When long-staple upland is ginned, care should first be taken to remove from the gin the roll of cotton left by the preceding bale of short-staple; for the mixing of even a little of this with long-staple cotton greatly lowers the selling value of the latter. This is because the spinning machinery in any one mill is arranged for a fiber of a definite length; the admixture of fibers of widely different lengths results in loss to the spinner, either by fibers wasted or by the making of thread of undesirable quality.

**285. Care of bales. Compressing.** As cotton does not readily absorb large amounts of moisture, farmers and warehousemen often leave bales of cotton exposed for weeks or

months to the weather (Fig. 115). This results in darkening and weakening the fibers in the outer layers, and consequently in a decreased selling value. Cotton bales should be kept continuously under shelter. If it becomes necessary to leave them uncovered, they should rest on poles or timbers laid on the ground, so that no part of the cotton bale touches the moist soil.

Most cotton that is to be exported, or transported great distances, is first shipped to "compresses," where the size of the bale is still further reduced by the application of enormous pressure (Fig. 116).

In some processes now coming into use, cotton, as soon as ginned, is immediately compressed into bales of very great density ready for export. One great advantage of thus compressing it at the gin is the more complete and careful covering of the bale with new closely woven cloth. On the other hand, the ordinary compress utilizes a part of the coarse, heavy, and usually cut or torn covering that was originally placed on the bale at the gin.

**286. Commercial classes, or grades, of cotton.** Cotton is bought and sold according to quality, or grade. When farmers sell, unless the number of bales is very large, a decision as to the grade or quality is usually made by the buyer, the seller being ignorant, as a rule, of the exact quality of cotton that he is selling. To enable farmers to know better what grade of cotton they sell, most Agricultural Colleges in the Cotton Belt now employ experts to give instruction in cotton classing to those students who are pursuing an agricultural course.

The classing of cotton can not be learned without practice under an expert, and never very quickly.

In large transactions, especially between business firms or corporations, experts representing both parties pass judg-

ment on the grade, and any difference in classification is arbitrated by disinterested experts.

Number 5, or *middling* white cotton, is the central starting point, or basic grade. The word "strict" prefixed to the word "middling" or to any other grade name lifts the grade by one; the word "good" thus prefixed lifts the grade two places. These same terms are not only used for the white grades of cotton but are also employed with the same meaning under the various groups of discolored cotton.

The nine grades of white cotton, arranged in order of value, are the following:

- No. 1 or middling fair
- No. 2 or strict good middling
- No. 3 or good middling
- No. 4 or strict middling
- No. 5 or middling
- No. 6 or strict low middling
- No. 7 or low middling
- No. 8 or strict good ordinary
- No. 9 or good ordinary

Cotton of the grade "middling fair" is comparatively rare. The greater part of the crop of the Southern States usually consists of the following grades, arranged here in order of value:

- No. 2 or strict good middling
- No. 3 or good middling
- No. 4 or strict middling
- No. 5 or middling

In years when continued rains occur during the fall, the crop may consist largely of the following still lower grades:

- No. 6 or strict low middling
- No. 7 or low middling

The grade of cotton is determined by a number of considerations. In general, the grade depends principally on (1) the amount of trash, (2) the color of the fiber, and (3) the amount of "nep," or tangled immature fibers. As a rule, the grades from best to lowest are supposed to express in some measure a decreasing percentage of waste material in spinning.

The preferred color is snow-white or slightly creamy, that is, with the faintest suggestion of a yellowish cast. A low grade is given to samples of cotton which possess even the faintest suggestion of blue, which is a quality usually due to long exposure of the open cotton to the weather and hence an indication of weakness of fiber.

Under acts of Congress and agreements within the cotton trade, American cotton, no matter in what country sold, is now classified by the official American (universal) grades. These correspond to actual samples of the various grades maintained by the United States Department of Agriculture under conditions that prevent deterioration. Duplicate sets of these samples, officially graded and certified as to correctness, may be purchased from that Department. The latter are the standards with which commercial cotton firms and coöperative cotton marketing associations compare, when necessary, the samples from the bales that they buy or sell.

From the table in **288** we note that the 31 grades of short staple cotton fall into seven groups. The nine grades of the first group, known as *white standards*, are all free from stains or tinges of color. Each of the other six groups contains a smaller number of grades, distinguished by the presence of a particular kind or degree of discoloration, as spots, tinges, stains, etc., and these command correspondingly lower prices.

**287. Tinges and stains.** If lint cotton shows patches of faint color, it is designated as "tinged"; if the color is decided and distinct, it is classed as "stained." Both tinges and stains are usually due to contact with red or other strongly colored soil or to injured bolls. The price of stains is somewhat below that of tinges, and considerably below the price of unstained or white cotton of otherwise the same grade. This emphasizes the loss in allowing pickers to mix with white cotton the stained locks that are usually found lying on the ground.

**288. Differences in value between the commercial grades.** There is no fixed difference in the value of any two grades. The demand determines this difference, which varies from year to year. Usually the following general statements hold true:

(1) The difference in price between any two adjacent grades of *good* cotton is less than between any two of the *lower* adjacent grades.

(2) When the greater part of any year's crop consists of the lower grades, the difference in price in favor of the upper grades is greater than usual, because of the strong competition, under these conditions, for the small amount of cotton of the upper grades.

The following reference table contains a complete list of the 31 American standard grades for short-staple cotton, arranged under each group in order of value. The same table indicates the average price above ("on") or below ("off") white middling cotton that prevailed in ten markets early in January, 1924, 1923, 1922, and 1921 respectively. The numbers express hundredths of one cent a pound; for example, the figure 181 "on," for middling fair, on January 5, 1924, indicates that this grade that day commanded a premium over middling of 181 points or 1.81 cents a pound.

## AVERAGE SPOT COTTON QUOTATIONS FOR JANUARY 5, 1924

(Price of No. 5 and middling spot cotton for January 5, the commercial differences in price between No. 5 and other grades of American upland cotton, and average differences and prices for the corresponding day in previous years.)

GRADE	AVERAGE			
	Jan. 5, 1924	Jan. 6, 1923	Jan. 7, 1922	Jan. 8, 1921
White standards:	<i>On</i>	<i>On</i>	<i>On</i>	<i>On</i>
No. 1 or Middling fair . . . . .	181	105	213	345
No. 2 or Strict good middling . . . . .	148	80	165	290
No. 3 or Good middling . . . . .	118	55	108	228
No. 4 or Strict middling . . . . .	73	31	58	123
No. 5 or Middling (Price) . . . . .	34.23	26.56	17.75	14.40
	<i>Off</i>	<i>Off</i>	<i>Off</i>	<i>Off</i>
No. 6 or Strict low middling . . . . .	108	37	89	218
No. 7 or Low middling . . . . .	243	79	210	438
No. 8 or Strict good ordinary <sup>1</sup> . . . . .	385	133	330	598
No. 9 or Good ordinary <sup>1</sup> . . . . .	520	193	435	740
Spotted:	<i>On</i>			
No. 3 or Good middling . . . . .	55			
	<i>Off</i>			
No. 4 or Strict middling . . . . .	3			
No. 5 or Middling . . . . .	85			
No. 6 or Strict low middling <sup>1</sup> . . . . .	201			
No. 7 or Low middling <sup>1</sup> . . . . .	332			
Yellow Tinged:	<i>On</i>			
No. 2 or Strict good middling . . . . .	26			
	<i>Off</i>			
No. 3 or Good middling . . . . .	17	3	46	98
No. 4 or Strict middling . . . . .	71	44	136	203
No. 5 or Middling <sup>1</sup> . . . . .	183	123	236	343
No. 6 or Strict low middling <sup>1</sup> . . . . .	307	175	348	533
No. 7 or Low middling <sup>1</sup> . . . . .	437	230	448	750
Light Yellow Stained:				
No. 3 or Good middling . . . . .	77			
No. 4 or Strict middling <sup>1</sup> . . . . .	138			
No. 5 or Middling <sup>1</sup> . . . . .	213			
Yellow Stained:				
No. 3 or Good middling . . . . .	133	79	220	300
No. 4 or Strict middling <sup>1</sup> . . . . .	195	153	310	413
No. 5 or Middling <sup>1</sup> . . . . .	265	210	415	555
Gray:				
No. 3 or Good middling . . . . .	30			
No. 4 or Strict middling <sup>1</sup> . . . . .	81			
No. 5 or Middling <sup>1</sup> . . . . .	144			
Blue Stained:				
No. 3 or Good middling <sup>1</sup> . . . . .	125	105	268	383
No. 4 or Strict middling <sup>1</sup> . . . . .	176	153	358	508
No. 5 or Middling <sup>1</sup> . . . . .	264	203	450	630

<sup>1</sup> "These grades are not tenderable on future contracts made subject to Section 5 of the United States Cotton Futures Act, as amended, on the future exchanges at New York and New Orleans."

**289. Premium for long-staple cotton.** Strange as it may seem, length of fiber does not usually greatly influence the grade, but it does determine the price; length of staple is considered as *spinning quality*, or *character*, and is independent of the grade. Thus there is middling cotton of the ordinary short-staple kind, and middling long-staple, the two selling at widely different prices.

This premium or extra price per pound over middling short-staple varies greatly with the length of the staple and in different years.

The following reference table records the premium over short-staple *middling*, in points (each one one-hundredth of a cent), per pound for various lengths of middling long-staple cotton, as indicated by sales in New Orleans at comparable dates in November of 1923, 1922, and 1921 respectively:

AVERAGE PREMIUMS FOR LONG-STAPLE LENGTHS OF THE  
GRADE NO. 5, OR MIDDLING, NOVEMBER 10, 1923,  
WITH COMPARISONS

	NEW ORLEANS		
	Nov. 10, 1923	Nov. 10, 1922	Nov. 12, 1921
No. 5 short staple . . . . .	<i>Cents</i> 33.00	<i>Cents</i> 26.37	<i>Cents</i> 16.25
<i>Length</i>	<i>Points</i>	<i>Points</i>	<i>Points</i>
1 $\frac{1}{8}$ in. . . . .	100	150	225
1 $\frac{1}{4}$ in. . . . .	175	375	600
1 $\frac{3}{8}$ in. . . . .	275	550	1,600
1 $\frac{1}{2}$ in. . . . .	400	800	1,400
1 $\frac{5}{8}$ in. . . . .	500		
1 $\frac{3}{4}$ in. . . . .	600		

"Quotations reported on November 9, 1923, for Pima American-Egyptian cotton f. o. b. New England mill points were as follows: No. 1 grade, 40¢ per pound; No. 2, 39¢; No. 3, 38¢."

(From *Crops and Markets*, United States Department of Agriculture, November 17, 1923.)

**290. Coöperative marketing of cotton.** Coöperative cotton-marketing organizations have been formed in recent years. These grade and sell the farmer's cotton as his agent. They have the advantage over selling by farmers individually in that they command the service of expert cotton salesmen. It is the business of the sales managers to keep constantly posted as to prices so as to be able to sell when and where the highest prices can be obtained. Their usual plan is to distribute sales over many months and thus to discourage violent fluctuations in price. The usual procedure of coöperative-marketing organizations is to form pools or sales lots of cotton. Each pool consists of bales of but a single grade. Each farmer receives the *average* price (less expense of sale) that is obtained for the particular pools in which his cotton is included.

### LABORATORY EXERCISES

(1) As part of the practice to accompany this chapter a ginnery should be visited, and inspection made of the parts of a gin while it is not in motion.

(2) **Price problems.** (a) Calculate from the table in **288** the difference in value in New Orleans, January 5, 1924, between a 500-pound bale of good middling and of strict low middling. (b) Similarly, calculate the difference in value between a bale of good middling and of strict low middling, as shown by recent newspaper price quotations for the city to which most of the cotton of your community is shipped.

(3) While it is not advisable for instruction in cotton classing to be given by any except experts of long experience in cotton buying and classing, it may be possible for samples of middling cotton to be procured by the school and for the pupils to become somewhat familiar with its characteristics.

### ADVANCED TOPICS

A. Practice in cotton classing.

B. The business procedure in the marketing of cotton produced locally or in the state.

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## CHAPTER XVIII

### COTTON — HISTORY AND STATISTICS

Cotton appears to be a native of the tropical parts of both hemispheres. The cotton plant was grown in India many centuries before the beginning of the Christian era. Until about a century ago, India continued to produce most of the world's supply of cotton; it now ranks as second only to the United States in the amount produced. Gradually the cultivation of cotton spread from India until at least small areas were grown in Egypt and other parts of northern Africa, in Spain (where cotton was probably introduced by the Moors), and in Italy.

Egypt, now the third largest producer of cotton in the world, probably learned cotton culture at a much later date than did the inhabitants of India.

England, which now manufactures more cotton than any other country, apparently did not manufacture cotton cloth until about the seventeenth century.

**291. History in America.** Columbus found cotton growing in the West Indies in 1492, as did Cortez in Mexico in 1519. Indeed, at that time cotton constituted the principal clothing of the natives of Mexico. A few years later explorers found cotton growing in Peru and Brazil. It is interesting to note that the American Indians inhabiting what now constitutes the cotton-growing states of the Union appear to have been without cotton, while their contemporaries of nearly all nationalities to the southward grew and used this

plant in countries where in modern times its culture has made relatively little progress.

Cotton manufacturing was greatly stimulated by the inventions of Arkwright, Crompton, Cartwright, and Watt in the eighteenth century. To supply the demand for raw cotton thus stimulated, cotton culture was extended in India, along the shores of the Mediterranean, and in Brazil. At that time the southern part of the United States was producing only a few bales for export and not enough to supply its own people with cotton clothing.

In 1764 the American colonies shipped eight "bags" of cotton to Liverpool, and this probably represented the entire export of that year from the American colonies.

**292. The invention of the cotton gin.** In 1793 Eli Whitney, then living in Georgia, applied for a patent on a saw gin. Prior to that time, hand picking was the rule, and only a rude form of roller gin was known. The immediate effect of the invention of Whitney's saw gin was greatly to increase the production of American cotton. In the period of 122 years, from the invention of Whitney's gin to 1914, the cotton crop produced in the United States increased so that it was about eight hundred times as large at the end as at the beginning of this period.

Up to the time of the beginning of the World War American cotton production continued to increase and usually doubled about every twenty years. It reached its maximum in 1914, when the yield in the United States was 16,135,000 bales. Since that date production has notably decreased, reaching its minimum in 1921, when the crop was only 7,954,000 bales. The average for the three-year period ending with 1923 was less than 10,000,000 bales. The decrease of nearly 5,000,000 bales for these recent years, as compared with the average of the four years ending in 1914,

has been partly due to the reduced buying power of European nations and partly to changes in labor conditions at home. However, most of this decrease of about 5,000,000 bales annually is the direct and indirect result of the further spread of the cotton-boll weevil.

The trend of cotton production in the United States is shown below:

#### COTTON PRODUCTION

YEAR	BALES PRODUCED
1790 . . . . .	8,889
1810 . . . . .	269,360
1830 . . . . .	1,038,847
1850 . . . . .	2,454,442
1870 . . . . .	4,352,317
1890 . . . . .	8,652,597
1910 . . . . .	11,609,000
1914 . . . . .	16,135,000
1921 . . . . .	7,954,000
1923 (December, 1923 report) .	10,081,000

The production of cotton in the United States did not permanently rise above 1,000,000 bales until 1832, nor above 3,000,000 bales until 1851. The crop in round numbers was about 4,000,000 for each of the three years preceding the Civil War. During that war cotton culture was largely discontinued, the production dropping to 300,000 bales in 1864. Not until 1875 did the annual cotton crop remain permanently above 4,000,000 bales.

**293. Value and extent of the American crop; production by states.** In the first few decades of the twentieth century the American cotton crop has usually ranged between 11,000,000 and 13,000,000 bales.

The area of cotton picked in 1923 was estimated at 37,420,000 acres. The lint and seed of a single crop are usually worth about \$1,500,000,000. Less than half of the lint is exported. Cotton shipped abroad, together with cottonseed oil and meal, annually brings into the United

States about \$700,000,000, or considerably more money than foreign nations send into this country for any other single crop. The other part of the cotton crop, made into cloth in the United States, supports the cotton textile in-



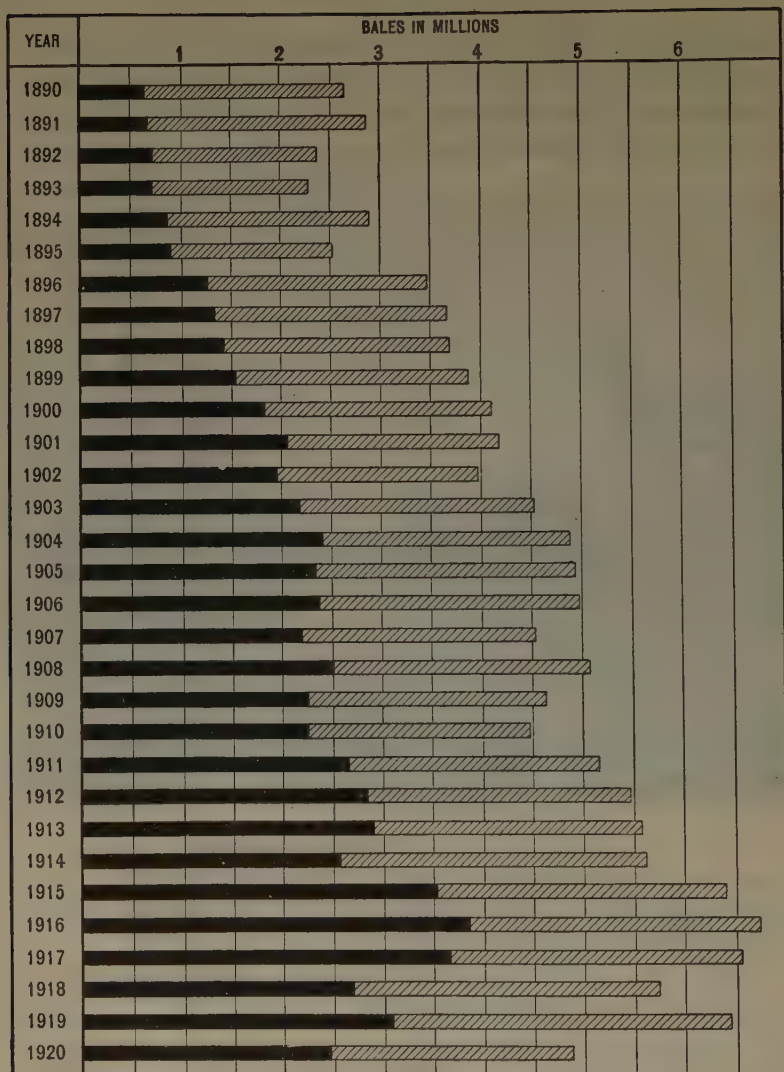
*Photo by Foltz*

Fig. 117. — Cotton shipping at Savannah

dustry, one of the most important American manufacturing enterprises (Fig. 118).

Only ten American states produce large amounts of cotton. These are the following:

Alabama	Mississippi	South Carolina
Arkansas	North Carolina	Tennessee
Georgia	Oklahoma	Texas
Louisiana		



*Courtesy U. S. Dept. of Agriculture*

**Fig. 118. — Raw cotton taken by United States mills**

The black bar represents millions of bales used by Northern mills. Southern mills now take more than half of the cotton crop.

Other states together produce about three per cent of the American crop.

The important cotton-growing states embrace less than one fourth of the area of the United States. Yet this small part of the country furnishes the most valuable article of export from the farms of the nation.

Both the Census Bureau of the United States and the Department of Agriculture devote much attention to the gathering of statistics relative to the production of cotton. Cotton crops of recent years, expressed in round numbers in 500-pound gross weight bales, are given in the following table:

TABLE XII. COTTON CROP OF THE UNITED STATES

	ROUND NUMBERS OF 500-POUND BALES			
	1920	1921	1922	1923
United States <sup>1</sup> . . .	13,440,000	7,954,000	9,964,000	10,140,000
Alabama . . . . .	663,000	580,000	835,000	587,000
Arizona . . . . .	103,000	45,000	42,000	78,000
Arkansas . . . . .	1,215,000	797,000	1,040,000	628,000
California . . . . .	75,000	34,000	34,000	54,000
Florida . . . . .	18,000	11,000	25,000	12,000
Georgia . . . . .	1,425,000	787,000	725,000	588,000
Louisiana . . . . .	388,000	279,000	357,000	368,000
Mississippi . . . . .	895,000	813,000	1,101,000	604,000
Missouri . . . . .	79,000	70,000	149,000	121,000
North Carolina . . . .	925,000	776,000	852,000	1,020,000
Oklahoma . . . . .	1,336,000	481,000	635,000	656,000
South Carolina . . . .	1,623,000	755,000	530,000	770,000
Tennessee . . . . .	325,000	302,000	400,000	228,000
Texas . . . . .	4,345,000	2,198,000	3,222,000	4,342,000
Virginia . . . . .	22,000	17,000	25,000	51,000
All other states . . . .	13,000	9,000	15,000	33,000

**294. Production of cotton seed.** For each bale of 500 pounds there is usually produced half a ton of cotton seed. The greater part of the cotton seed produced is manufactured

<sup>1</sup> The 1924 crop was officially forecasted in October at 12,675,000 bales.

into cottonseed oil, meal, cake, hulls, and linters, the latter being a very short low-priced fiber adhering to the seed after ginning. The remainder of the crop is used as a feed for cattle, as seed for planting, and (rarely in recent years) as fertilizer.

**295. Distribution of cotton culture in the United States.**

The northern line of the Cotton Belt of the United States extends from near Norfolk, Virginia, in a southwesterly direction to the northeastern part of Georgia; thence in a northeasterly direction through Tennessee and into Kentucky, crossing the Mississippi River just north of the mouth of the Ohio. Thence the line extends almost directly west through the southern part of Missouri, excluding the northwestern part of Arkansas. The Cotton Belt includes practically all of Oklahoma and all of Texas except the extreme western part. Small isolated areas producing small amounts of cotton are found in the irrigated regions of New Mexico, California, and Arizona.

**296. The principal foreign cotton-producing countries.**

The United States has been producing about two thirds of the supply of cotton used in the world's mills.

Next to the United States, comes India with an annual crop of nearly 4,000,000 bales. Egypt's production of about 1,200,000 bales consists of long-staple cotton. China has a commercial crop estimated at more than 1,500,000 bales, and a still larger amount is manufactured into cloth by Chinese hand looms.

Among countries producing much smaller quantities, come Asiatic Russia, Brazil, Mexico, Peru, Chosen (Korea), Australia, and Turkey.

**297. Foreign competition in cotton growing.** It is often said that the United States has a practical monopoly of cotton culture. The following facts suggest the possibility of constantly increasing competition from abroad:

(1) The stupendous injury inflicted on the American crop of recent years by the boll weevil has greatly reduced the profits in cotton culture and hence the annual production in the United States. It has so reduced the profits of the cotton growers as to drive many farmers into others lines of activity.

(2) Great efforts have been made during the past few years, especially by the British government in its African possessions, to build up centers of cotton production. These attempts, unlike those during the Civil War, are being made in countries believed to have climatic conditions well suited to the growth of the cotton plant. In some of these countries, notably in Africa, these efforts are resulting in a continual increase in the annual production.

(3) A high price for American cotton always stimulates foreign cotton production, and in the early twenties the average price of cotton has been higher than in preceding decades. High prices would have the effect of increasing cotton production abroad, especially in Africa and Asia.

(4) Improvement in the methods of cultivation in India can greatly increase the cotton production of that country. Extension of the government's irrigation system will have the same effect. Improvement in the quality of Indian fiber is possible.

(5) In Egypt the government is extending the irrigation system, thus increasing the area of cultivated land and making possible even larger yields to the acre by reason of more frequent irrigation. This is partly offset by the injury inflicted by the pink bollworm.

(6) Asiatic Russian commercial production of cotton has been disorganized by conditions prevailing in Russia during and since the World War; in due time that country may at least attain its former production of about 750,000 bales.

**298. Program for the American cotton grower.** The best steps for the American cotton grower to take in order to meet any foreign competition that the future may bring forth consist (1) in producing cotton by more intensive methods, which lowers the cost of producing each pound of lint; (2) in more largely employing machinery in the cultivation and harvesting of this crop; and (3) in improving the usual wasteful and slovenly method of covering and handling American bales.

### LABORATORY EXERCISES

From the latest United States Census Reports on Agriculture, students should calculate and record:

- (a) The proportion of the total crop produced by their state.
- (b) The proportion of the crop of their state produced by their county.
- (c) A list of the ten counties in their state producing the greatest number of bales.
- (d) The average yield per acre of lint cotton in the United States.
- (e) The average yield per acre of lint cotton in five selected counties in their state.

### ADVANCED TOPICS

A. A statistical study by decades of the amounts and percentages of the American cotton crop (1) manufactured in this country and (2) the amounts exported, with the geographical distribution of the exports.

B. A statistical study of the world's commercial supply of cotton by countries and by years.

C. A library study of the methods and prospects of cotton production in the foreign countries making the largest crops.

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## CHAPTER XIX

### THE MEXICAN COTTON-BOLL WEEVIL

No other insect or disease attacking any of the staple crops of this country should so earnestly engage the attention of the American public as the Mexican cotton-boll weevil (*Anthonomus grandis*). The conquest of this well-fortified enemy concerns not alone Southern farmers but the entire nation, for this insect devastates the crop that brings more money into the United States from abroad than does any other crop and on which depends the prosperity of the textile and related industries and the livelihood of millions of farmers.

**299. Character of losses caused by the boll weevil.** The boll weevil is the most destructive insect enemy (Fig. 119) that has ever attacked any considerable area of cotton in the United States. It not only destroys directly a large proportion of the crop, but indirectly it reduces the acreage and production. This is because it creates panic and undermines the cotton grower's credit.



*Photo by W. E. Hinds*

**Fig. 119. — Mature boll weevil**  
(enlarged)

Moreover, the boll weevil greatly increases the cost of producing a pound of cotton. This is (1) because its presence necessitates extra expenditures for poison and labor and (2) because there are fewer pounds of cotton produced on an acre and, therefore, a larger charge against each pound to cover the overhead and other expenses.

**300. Extent of injury.** The direct loss alone has been estimated as an average in recent years at probably more than 2,000,000 bales annually. At 20 cents a pound this gives more than \$200,000,000 as the annual financial loss. Hester, the cotton statistician, estimates the loss in the early twenties of this century at \$300,000,000 a year.

The United States Department of Agriculture compiled the estimates made on this point by its thousands of crop reporters, representing all cotton-producing counties (*Year-book*, 1921, p. 714). The results showed an average estimated loss by boll weevil of 13.20 per cent in 1919; 19.95 per cent in 1920; and 30.98 per cent in 1921. For earlier years, when a smaller part of the Cotton Belt was infested, the proportion of injury was lower.

In typical states the percentage of destruction in round numbers has been as follows: In Alabama only the extreme southwestern corner of the state was invaded in 1910, and not until 1913 did the loss rise to nearly 5 per cent; in 1915 it was 16, then successively 28, 29, 12, 29; and in 1920, and 1921 it was 36 and 32 per cent respectively.

Georgia was entered by the boll weevil in 1915, and by 1920 its loss had risen to 30 per cent. In 1921 it was 45 per cent.

Mississippi suffered a loss of 4 per cent in 1909, which rose by 1913 to 34 per cent; its loss in 1920 was 32 per cent and in 1921, 30 per cent.

Although much of the Texas crop is produced in regions too dry to be seriously injured by boll weevils, yet the loss

from this insect in Texas in 1920 reached nearly 20 per cent of a normal crop and rose to 34 per cent in 1921.

The extent of boll-weevil injury varies widely for the same state in different years, for this depends largely on the weather. Even more variable are the results on any one farm, where one year the crop may be a little below normal and another year only one quarter of a crop. Even in the same year adjacent farms suffer very unequal losses.

**301. Food of the weevil.** The injury done by this insect is practically confined to the squares and bolls. The squares are decidedly preferred, and as long as these are present in abundance but little damage is done to the larger bolls. This preference for the squares, rather than for the older forms, makes it possible for farmers to grow cotton in spite of the boll weevil.

This is done by *hastening the early growth of the plants so that many bolls will form and pass the danger point before the weevils become very numerous.* After the weevils become very abundant in August, they sometimes destroy every square in a field, so that no late blooms appear.

Injury is done by the mature weevil (Fig. 119), which feeds from the outside of the square or boll, but chiefly by the grub within (Fig. 120).



Courtesy U. S. Dept. of Agriculture

Fig. 120. — Boll-weevil larva in a square

The mature insect can live for a short time on the tender leaves or growing buds of the cotton plant, a fact which is important to remember in considering means of combating this pest.

The cotton-boll weevil does not multiply on any plant except cotton nor does it eat any other common plant. This fact may be utilized in starving the insect by depriving it, late in autumn, of green cotton plants, its only food.

**302. Stages in the life of the boll weevil.** In the life of the cotton-boll weevil, as in that of most other insects, there are four stages. These are: (1) the egg; (2) the larval, or grub, stage, which is the growing period; (3) the pupal, or changing, stage, when this insect is comparatively inactive and no food is taken; and (4) the adult, or mature stage, which is the period of activity and of egg laying. These stages require, in summer, for the egg, three or four days; for the larva, six to twelve days; for the pupa, three to five days; the mature insect may begin laying when less than twenty-one days old; all this means a lapse of only twenty-five days for one complete life cycle, or four or five teeming generations within one growing season.

**303. How the injury is done.** Injury to the forms, or young fruits, of the cotton plant are due partly to punctures made by the mature weevils for the purpose of obtaining a food supply for themselves, but chiefly to the young grubs, which develop within the square or boll where the egg has been laid by the mature weevil.

A few days after an egg has been laid in a square, the color of the latter becomes paler, and the surrounding leafy parts flare, or spread outward. The square may remain hanging on the plant or it may drop to the ground, carrying the larva or grub within. It was found in experiments in Texas that among the immature insects in the

fallen squares, about one third developed into adult weevils. The remainder were killed by their insect enemies or by the rapid drying of the squares where they lay in strong sunlight on the hot soil.

The dead squares that continue to hang to the plants bring forth a larger proportion of mature weevils than do the fallen squares, probably because in the hanging squares larvæ are less exposed to the attacks of their principal insect enemies, the ants. Hence some farmers attempt to brush off as many of these infested squares as possible, by attaching a brush, or a stick wrapped with cloth, to the cultivating implement. Some authorities regard this detail as of but slight value.

The larvæ developing within the boll may result in the destruction of only one lock or of the entire boll.

Feeding punctures may cause the square to die or the boll to rot.

**304. Rapid multiplication.** One of the reasons why the cotton-boll weevil is destructive is because it multiplies very rapidly. The time from the laying of the eggs to the appearance of the mature weevil is less than 25 days. The average time between the egg-laying periods of any two generations is about twenty-five days, and a single pair of weevils coming from their winter quarters in the latter part of spring in southern Texas might there, before the occurrence of frost, have over 12,000,000 descendants.



*Courtesy U. S. Department of Agriculture*

**Fig. 121.** — Cotton square from which a boll weevil has escaped

In southern Texas there may be as many as five generations; but in the part of the Cotton Belt farther north it is probable that the usual number of generations averages four a year.

**305. Where the winter is spent.** The boll weevil passes through the winter in the mature, or weevil, stage. Therefore one effective method of fighting the boll weevil aims at reducing as low as possible the number of adult weevils that live through the winter. Fortunately, of the weevils that go into winter quarters the greater portion die before spring. In Texas and Louisiana the percentage of weevils living through the winter has varied from less than 1 per cent to more than 50 per cent of those that entered winter quarters. The proportion of those that survive can be reduced largely by the destruction of the trash under which they usually take shelter throughout the winter.

The hiding places preferred are: (1) in the empty cotton burs and in other litter in the cotton field; (2) in the fallen leaves and in the bark and moss of the woods; (3) in cornstalks, grass, blackberry patches, and other litter or vegetation adjacent to the cotton fields; and (4) around and in buildings and haystacks.

All of this suggests the need of plowing under deeply, or otherwise destroying, as much as practicable of the litter and vegetation adjacent to cotton fields and the advisability of keeping the fields in a clean and neat condition.

**306. Principal methods of combating the boll weevil.** The methods of reducing injury from boll weevils may be grouped as follows:

(1) Standard cultural methods (307, 308, 309).

(2) Picking of weevils from the young plants before the squares appear.

(3) Picking infested squares during the first few weeks after squaring begins.

(4) Applying poison to the buds of the young plants before squares form.

(5) Dusting the fruiting plants with the poison calcium arsenate (Fig. 122).

(6) The Florida method of stripping the squares, followed by immediate application of poison to the young plants.

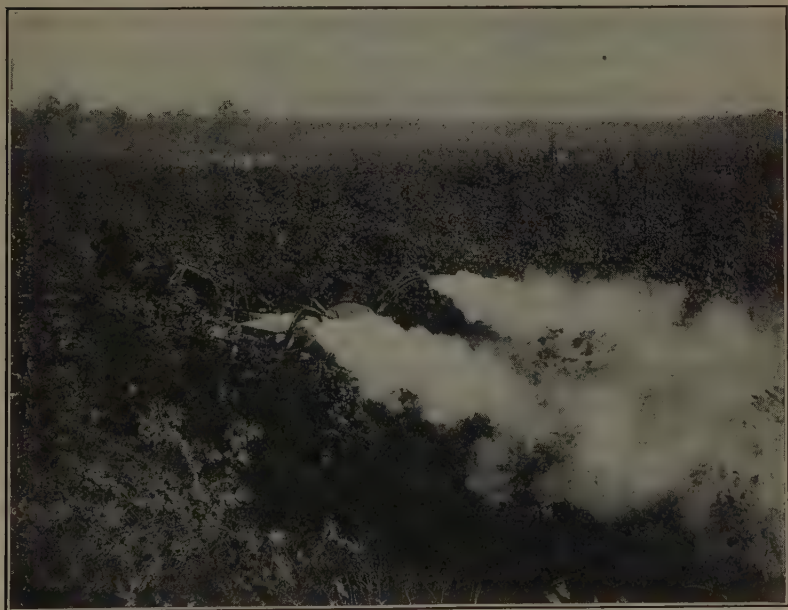


Fig. 122. — Fighting boll weevil with calcium arsenate. The poison is being applied as fine dust by a team-drawn machine

**307. Standard cultural methods.** Standard cultural methods that have been the main reliance up to 1923 in decreasing the damage from boll weevil include the following:

(1) The planting of early or medium-early varieties as soon as practicable.

(2) Hastening early growth of the plant by liberal fertilization, especially with mixtures rich in available phosphoric acid; and by enriching in advance the soil intended for cotton through the previous employment of a soil-improving legume.

(3) Thorough preparation of the soil and frequent and timely cultivation.

(4) Thick spacing in the drill.

(5) The destruction of cotton plants before frost and of other litter in which the weevils might otherwise hide in winter.

It is evident that the first three of these practices are easily included as natural parts of any good farming system. All of these topics except the last have been discussed in earlier chapters.

The main aim in most cultural methods is to force the growth of the cotton plant as rapidly as practicable. The purpose in doing this is to enable the cotton plants to set a large number of bolls before many generations of weevils have had time to come forth. Bolls of rather large size are not seriously attacked so long as there is an abundance of squares for the weevils then present. Hence the earlier bolls escape injury, and there should be enough of these to make a satisfactory yield.

**308. Cultivation.** Frequent cultivation is most important as a means of causing the plant to hasten its growth and to form squares more rapidly than the insects can puncture them. However, it is not under all circumstances a reliable means of destroying the immature stages of the boll weevil.

The condition needed for killing the immature insect is that degree of heat and dryness required for the quick drying of the inclosing square or young boll. Heat is

greatest on or very near the surface. Deep cultivation may bury the squares and their insect contents deep enough to afford the moisture necessary to keep both damp until the adult weevils hatch. Then the latter are able to crawl out from under several inches of loose soil. From this it follows that any cultivation should be shallow, so that the fallen infested squares may be buried no deeper than the shallow layer of soil that, on drying after cultivation, becomes intensely hot.

**309. The destruction of winter hiding places.** When cold weather approaches, or on the occurrence of a killing frost, boll weevils enter their winter quarters under all sorts of trash. Experiments have shown that if the weevils can be deprived of their food for a period of several weeks before cold weather occurs, they will be so weakened that most of them will die before spring.

Hence some farmers have effectively practiced the uprooting, piling, and burning in October, or a few weeks in advance of the usual date of killing frost, of the green cotton plants. This results in destroying great numbers of immature insects and starving the mature weevils.

However, this process is destructive to soil fertility. The nitrogen thus lost per acre from a fairly good crop is scarcely less than 20 pounds. A considerable amount of vegetable matter is completely lost. Even the potash and phosphoric acid which are left in the ashes become less valuable because not evenly scattered over the surface. The total loss in fertilizing value from burning a fairly good growth of plants on an acre is apparently not less than five dollars.

Far preferable, and also effective, is the plowing under before frost of the entire cotton plants, together with any other litter then in the field. However, to be effective, this plowing must be deep and all parts of the cotton plant

must be well covered with soil. This requires special devices for chopping or pulling down the cotton plants so that they may be covered completely by the furrow slice.

Soil thus plowed in the fall should, of course, not be left bare in the winter but should be sowed with one of the small grains or winter-growing legumes.

Even the mere uprooting of cotton stalks is advantageous.

A less effective, though helpful, treatment consists in turning a large number of cattle into the cotton fields before frost, so that they may *quickly* consume all leaves and young forms. This should be followed by the thorough plowing under of the stalks, so as to prevent young sprouts from putting out, for the weevils are able to subsist for a short time on these new growths. The early grazing or burying of cotton stalks in the fall is effective even though one's neighbors should not do likewise.

**310. Picking weevils from young plants.** The mature weevils that survive the winter do not all leave their winter quarters at the same time. Instead there is a period of gradual emergence covering many weeks, and in the greater part of the Cotton Belt it includes May and June. The long period during which the weevils are emerging from their winter quarters prevents poison applied at this time from killing all the weevils that survived the winter

However, the picking of weevils from young plants before the latter have formed squares is highly effective. For every female weevil now picked and destroyed may represent more than 100 weevils six weeks later, or thousands of weevils within a period of twelve weeks. Fortunately it is not always necessary to pick over the entire field but to give chief attention to the spots where weevils first appear. However, the insects may soon become so numerous that this operation becomes impracticable. The catching of

weevils from young plants can be made easier and quicker by employing a specially constructed bag of strong cotton cloth, the mouth of which is kept open by a barrel hoop, stitched into a hem a few inches from the open end of the bag. The open edge of the bag is turned inward so as to form a flap intended to impede the escape of the captured insects.

**311. Picking infested squares.** Both picking and poisoning of mature weevils are discontinued after they begin laying their eggs in the first squares on the young plants. The squares, usually about ten days after receiving eggs, fall or turn pale and their leaf bracts tend to separate, or flare. These infested squares, whether fallen or hanging to the plant, are sometimes picked and destroyed, or else treated as described in **315**. Picking is repeated about every fifth day until the natural shedding of squares and small bolls renders this operation too slow and costly. Indeed the picking of squares, which is effective only when thoroughly done, is at best tedious and expensive. It is usually advisable to practice poisoning (**312**) instead of picking infested squares, if one or the other operation be needed.

In very hot dry weather picking of squares is not necessary, for the immature weevils within are killed by intense heat and dryness.

**312. Poisoning weevils with calcium arsenate.** The boll weevil, in its egg, larval, and pupal stages, is entirely within the square or boll and beyond the reach of poisons. The adult weevil feeds but lightly on cotton foliage, eating, especially before the squares are abundant, a little of the tender leaf buds. Hence poison is most effective when it covers these buds.

On poisoned cotton the adult weevils are believed to be

killed chiefly by drinking the dew that holds calcium arsenate.

The application of poison takes the place of picking both (1) adult weevils from plants before squaring and (2) infested squares from older plants. It thus saves a great amount of labor but involves some cash expenditure for the purchase of calcium arsenate.

The slight extent to which the weevils feed on foliage made it necessary to manufacture a special poison to be employed against this pest. Research by the United States Department of Agriculture fortunately resulted in the preparation of an especially finely powdered form of calcium arsenate. This has come to be the main reliance in poisoning boll weevils. It is applied as a very fine dust by special machinery (Fig. 122). It is also employed as part of a sirup mixture.

*Sweetened poison or sirup mixture.* To the buds of young plants on which no squares have appeared calcium arsenate may either be applied from a dust gun or in a mixture with sirup and water. The sweetened mixture may be brushed against each terminal bud by means of a mop made by tying strips from burlap bags or corn shucks or other suitable material to the end of a stick.

The sweetened poison is made by mixing two pounds of calcium arsenate in half a gallon of water and then adding one gallon of sirup. This is mopped on the top of the young plants while the mixture is fresh; that is, before the sirup has fermented.

In Florida the sirup mixture was found to poison weevils in the buds of young plants more quickly and completely than did calcium arsenate dust. This gave it an advantage in a season when rains were frequent at about the time of application. Its quicker effect was attributed to

the sticky sirup holding the calcium arsenate more thoroughly in suspension in the dew. The investigator (George D. Smith) concluded that in the dewdrops poisoned by the dust the insoluble calcium arsenate largely settled, but that when weevils drank sweetened dew they took in both soluble and insoluble arsenic.

*Dusting.* The most popular machines are cart dusters on which the distributing fans are driven by the revolution of the cart wheels. Hand dusters are also extensively used. One hand duster is expected to serve for about ten acres of cotton and one cart duster for sixty acres. The best time of application is at night or in the early morning while the foliage is damp. Airplanes have occasionally been employed in the dusting of large areas.

Entomologists recommend that dusting of blooming cotton begin as soon as about one tenth of the squares are found to have become infested.

Four applications are recommended as a full treatment, each time about five pounds of calcium arsenate on an acre being used. If continued dry weather prevails only two or three applications may be required.

The interval advised between the first two applications is four or five days. The next interval may be longer, seven days or more, so as to determine whether the first two applications have checked the weevils. Two more dustings may be made similarly after about one tenth of the young cotton forms again show evidence that they contain eggs or larvæ.

**313. Results of dusting fruiting cotton plants.** The dusting of well-grown cotton with calcium arsenate has usually increased the yield to a profitable extent in average seasons. However, continued dry weather may so reduce weevil injury as to make poisoning seem an unnecessary expense.

On the other hand, heavy rains falling soon after poisoning occurs may wash off the poison and make it an unprofitable operation for that particular year.

The safest plan is to prepare for dusting as often as weather conditions make it advisable and to regard the expense as insurance against occasional severe loss, just as in the payment of fire insurance. The crop insurance afforded by poisoning has generally been profitable in regions of considerable summer rainfall when the results of a series of years are taken into consideration.

**314. The Florida method of weevil control.** In 1922 the Florida Experiment Station (*Bulletin* No. 165) and State Plant Board announced a new method of minimizing boll-weevil injury. This had been worked out by George D. Smith and had given an unusual degree of control at relatively slight expense, as tested on a number of farms in the northern part of Florida.

The Florida method consists in stripping every square from the young plants while there are only a few on each plant, and then in immediately poisoning with arsenate of lead or calcium arsenate. The adult weevils, deprived of their favorite food by the complete removal of the squares, are compelled to feed more freely than usual on the tender poisoned leaf buds. Poisoning is not repeated.

The essential detail consists in selecting a date for this double operation late enough to find practically all of the boll weevils emerged from their winter quarters, and yet early enough to find but few squares on the plants. In northern Florida this date was found to be about the end of the first week in June. Further north it is doubtless somewhat later.

Cotton plants thus freed of infested squares and of mature weevils remained free from infestation until after the time

of the usual migration, which there occurred in late summer. Meantime the plants fruited rapidly and at somewhat uniform dates, so that by the time of the usual migration of boll weevils, many bolls had attained such size as to be safe against serious injury.

By this method the average increase in yield in 1922 on many fields of poor land was 275 pounds for each acre; this was effected at a cost of only \$1.57 for poison and labor.

These experiments were repeated in 1923. The average increase of seed cotton per acre attributed to the treatment was 208 pounds where the calcium arsenate was mopped on the young plants as a sirup mixture; and 176 pounds where it was applied as dust. The total cost of the treatment, including all materials and labor of both stripping squares and poisoning, was respectively \$2.14 and \$2.41 per acre; this left an average profit from the treatment of \$19.31 where the sirup mixture was used and \$15.80 per acre where the young plants were dusted once.

This method proved practical even for poor land inadequately fertilized. The usual poison method, on the other hand, is recommended only when there is promise of a good crop.

**315. Enemies of the boll weevil.** The weevil has fewer insect enemies than most crop pests. This is probably because the mature weevil is protected with a hard coat, and because in its stages of larva and pupa, when not thus protected, it is inclosed within the square, or boll. However, there are some minute insects that lay their eggs in the body of the immature boll weevil while the latter is still in the square. On hatching, these smaller insects cause the death of the pest. None of these parasites offers promise of affording complete natural control.

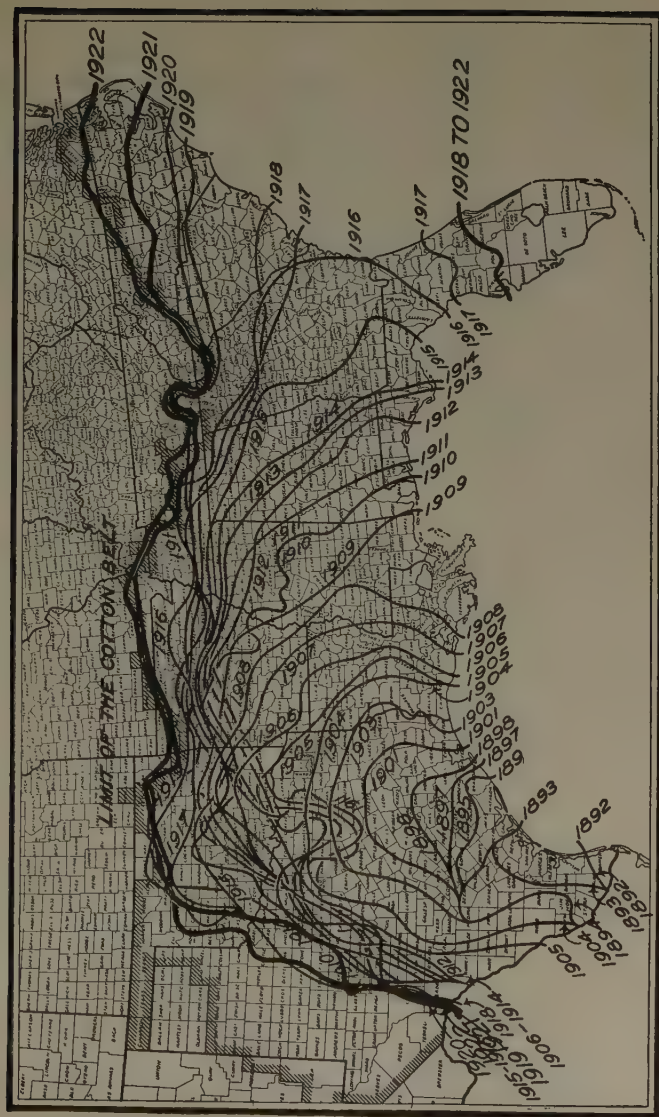
In order to utilize these enemies of the boll weevil most

fully, the squares that may be picked instead of being burned may be placed loosely in boxes, one side of which is made of screen wire. This should be fine enough (14 meshes to the inch) to prevent the escape of the weevils that may hatch; however, it will permit the escape of their minute insect enemies. If these cages are placed at intervals in the cotton field, it is claimed that these parasites will be turned loose in such quantities as to reduce appreciably the damage done by the boll weevil.

Several species of native ants destroy considerable numbers of the immature stages of the weevil. Some of the birds include boll weevils in their diet.

**316. Spread of the boll weevil.** Ordinarily the adult weevil flies but a few rods at a time. However, when food becomes scarce in the autumn, distances as great as fifty miles are traversed in a few days. This fall migration, apparently in search of food, explains the rapid spread of the boll weevil. The weevil has usually advanced less than fifty miles a year.

Crossing the Rio Grande from Mexico about 1892, the cotton-boll weevil has persistently spread eastward and northward, until by 1923, it had reached practically all of the cotton-growing counties except some of the dryer regions of western Texas and Oklahoma. Its progress northward has been less rapid than its eastward course. Cotton suffers least from boll weevils in the northern parts of the Cotton Belt. This is partly because of earlier autumn frost and colder winters there. It is also due to the smaller average rainfall of the summer months as the distance from the coast increases. When the rainfall for June, July, and August is less than 12 inches, weevil injury is much reduced. Where the summer rainfall rises above 14 inches, the growing of cotton becomes very hazardous. In regions having a sum-



Courtesy U. S. Dept. of Agriculture

Fig. 123. — Annual spread of the cotton-boll weevil

mer rainfall of more than 18 inches, cotton culture has been largely abandoned.

**317. Main aims in growing cotton in the presence of the boll weevil.** Only by practicing one or more of the methods of control previously mentioned may farmers in the humid regions expect to grow cotton at a profit. Moreover, all methods thus far adequately tested afford only partial control. Therefore, whatever means of fighting the boll weevil are employed, they should include intensive cotton culture, that is, such methods of fertilization and cultivation as promise to afford good yields. There must be so many squares formed that after the boll weevil has taken his toll, enough fruit will be left uninjured to mature a crop large enough to pay the usual expenses and the added cost of fighting the pest.

The main aim should be to cause the cotton plant to develop bolls early. The greater the prospective yield, the larger will be the number of bolls attaining early sufficient size to be comparatively safe by the time the weevils become overwhelmingly numerous in the latter part of summer or in September. *Earliness in the setting of bolls is the measure of success in growing cotton in infested regions.*

The presence of the boll weevil should stimulate farmers to produce their supply of food and forage and to grow for sale a greater variety of farm products and live stock than before the coming of the weevil. This gives an opportunity for rotation of crops, which enriches the soil and thereby makes easier the production of larger yields to the acre of cotton. Rotation is also a means of reducing the amount of injury inflicted on the cotton plant by the boll weevil and by other enemies.

**318. Relative damage in early and later years of boll weevil infestation.** The time of the weevil's entrance into

territory recently free from infestation is the annual period of fall migration, when the weevil flies long distances in quest of squares not already punctured. Hence the damage that first year is usually only slight. The second year may bring only moderate injury, or it may be so extreme as to demoralize farmers. The next few years are likely to be especially destructive, if weather conditions are favorable to the weevil. Thereafter, the injury tends to be somewhat less than in the early years of complete infestation though years of disaster may still occur. This apparent tendency for weevil injury to become somewhat less severe is chiefly due to the farmers' better knowledge of means of outwitting their insect enemy. It may be due partly also to an increase in the insect enemies of the boll weevil. However, natural enemies and weather conditions never permanently remove the menace.

**319. Permanence of the weevil's presence.** Contrary to the hopes once entertained by some farmers, the weevil does not ultimately disappear. Once established, the boll weevil is a permanent occupant, except as extremely unfavorable weather conditions may temporarily sweep it back from strips of territory in the region of the insect's northern or western outposts.

Even should every farmer adopt the most approved methods of growing cotton and poisoning weevils, there would always be left enough weevils to make necessary the annual fight against them. This added expense of combating weevils must go on from year to year, as an annually recurring tax. This financial burden is augmented by the cost of crop failure in years when weather conditions make futile man's wisest efforts in this unremitting warfare.

**320. Ultimate eradication of the boll weevil is possible.** The cotton-boll weevil may be eradicated completely when-

ever public sentiment shall decree that this be done. The method is simple and sure. The obstacles presented by the insect are completely surmountable. The difficulties that are formidable are those found in men's minds, not in nature. They consist chiefly in lack of information and faith, inexperience in coöperation, and unwillingness to make the sacrifices required for one year as the price of ultimate freedom from ruinous economic thralldom.

The boll weevil can support life on no plant but cotton. In the summer it can live without food for only a few weeks. It can multiply only in cotton squares or bolls. It has limited power of flight. These are facts well known to every scientist who has investigated the habits of this insect. Therefore, the starvation and sterilization of every single boll weevil is possible in any state or other extensive region where a united public sentiment results in allowing not a single cotton plant to grow for a period of one year.

Such areas of eradication should be more than 100 miles across and preferably several hundred miles wide. It would be entirely practicable for the cotton-growing states in succession, or successively in compact groups, to dispense for one year with the growing of cotton, and thus ultimately to destroy the last cotton-boll weevil within the United States. Then a permanent strip of cottonless country, or safety zone, could be maintained along the Mexican border.

**321. One possible grouping of states for boll-weevil eradication.** The movement for complete boll-weevil eradication might begin in any part of the boll-weevil region and the grouping of states for simultaneous eradication might be various. For example, if a national coöperative movement of this kind should begin in the eastern part of the Cotton Belt, cotton culture might be dispensed

with the first year in Virginia, North Carolina, and South Carolina; the second year in Florida, Georgia, and Alabama, and the eastern part of Tennessee; the third year in Mississippi, Louisiana, Arkansas, and the western part of Tennessee and northward; the fourth year in Oklahoma and northern and eastern Texas; and the fifth year in central, southern, and western Texas. This is only one of several feasible groupings.

Wherever a zone of territory temporarily without cotton should immediately adjoin one in which cotton is grown, there should be a border zone of perhaps 50 to 100 miles in width which would need to be kept free from cotton for a period of two years.

Thus in five years, or in some other period agreed on in advance by the cotton-producing states, the last cotton boll-weevil will have perished.

**322. Effect on total production.** There need be little diminution in the American production of cotton during the progress of extermination, for the area temporarily lost to cotton culture would be balanced largely by the added acreage in other states and by their increased use of fertilizers, and also, after a year or two, by the larger yields to the acre obtainable in the states then freed from the pest.

The conditions necessary to initiate and carry to a successful conclusion the complete extermination of the boll weevil include the following:

- (1) An overwhelming and united sentiment among Southern farmers and business men in favor of making the necessary sacrifices or business readjustments.

- (2) Coöperation among state legislatures, resulting in parallel legislation in the states affected, with possible constitutional amendments in some states.

- (3) Enabling or permissive legislation by Congress.

(4) Coöperation among farmers' organizations of the various cotton-growing states, especially with a view to insuring adequate market demand for other farm products in the territory deprived of cotton for any one year. This need would be partially met by the greater temporary demand for farm-grown supplies in the state in which an increased acreage of cotton would naturally be grown during the period when other states would be engaged in eradicating the boll weevil.

(5) Somewhat similar coöperation among groups of business men in the cottonless region with those of the states then growing cotton, so as to insure a normal consumption of the industrial products of the former area, especially by means of their wider distribution. A sixth condition is desirable, though possibly not essential. This would be partial compensation to the farmers of the area temporarily deprived of cotton; funds for this purpose might well be raised by an assessment on every bale of American cotton grown that year.

Such a program would encounter many obstacles and would need to be preceded by a long and universal campaign of education as to the benefits and feasibility of the complete eradication of the cotton-boll weevil, so that all classes of people would heartily support the movement. The gains through all future years would be so stupendous that public opinion could doubtless ultimately be aroused and united in effecting the eviction of this oppressive invader.

### LABORATORY EXERCISES

(1) When cotton is mature pick the seed cotton from a dozen widely opened bolls that have escaped attack by the boll weevil. With this compare the entire contents of ten bolls in each of which boll weevils have damaged some of the locks; for each lot note relative colors of lint, weights of seed cotton, and numbers of well-developed seeds.

(2) Write a list of the places on the farm best known to you where the boll weevil is most likely to find shelter in winter. What means could be used to decrease the number of weevils spending the winter in such hiding places?

(3) Ask at least one farmer to give an estimate, for you to record, on the usual yield of an acre of cotton on his farm, both before and since the coming of the boll weevil; also a report on the usual number of acres of cotton that were grown on his farm before and since the arrival of this insect.

(4) In regions where cotton is not grown students may substitute for the above exercises a tabulation of statistics (from the Census Reports or from the latest *Yearbook* of the United States Department of Agriculture), showing the number of bales of cotton produced in any one selected state and for the entire South, both for years when weevils were widely spread and for selected years before they covered most of the area.

### ADVANCED TOPICS

A. A more detailed study of statistics of cotton production in the South, in your state, and in your county with estimates of weevil losses.

B. A community cotton survey to ascertain the effect of the boll weevil on the local acreage and acre yield of cotton.

C. A library study of the results of experiments in poisoning weevils.

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## CHAPTER XX

### COTTON — OTHER INSECT ENEMIES; DISEASES

Cotton has other enemies, second only in importance to the boll weevil. Among the other insects attacking cotton, those that have caused most damage are the bollworm within the green bolls and the cotton caterpillar and the red spider on the leaves. Of fungous diseases the most destructive are wilt, root rot, boll rot, and various diseases of the foliage.

#### OTHER INSECT ENEMIES

**323. Life history of the bollworm.** The bollworm (*Chloridea obsoleta*) is one of the most widely distributed enemies of cotton. The only parts of the plant injured are the squares, or bolls, which are eaten into and the interior destroyed by the caterpillar stage of a moth. Other plants that are much injured by the same worm are corn (164) and tomatoes.

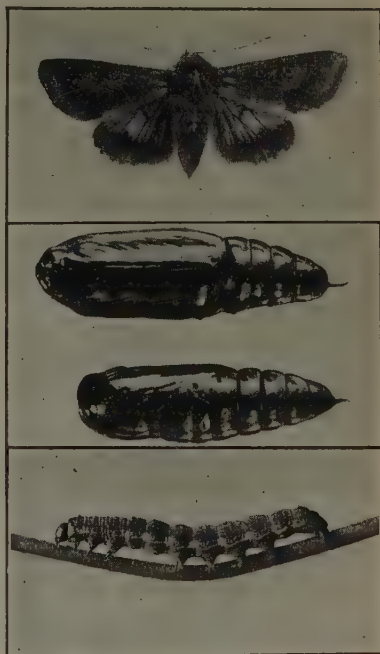
The parent is a moth (Fig. 124) which may lay more than one thousand eggs. These are laid on all parts of the cotton plant, but especially on the leaves. On hatching, the young worms, which are too small to be seen easily, wander about for a few hours or days, eating small amounts of the surface tissue of cotton leaves and buds. This is the only time when poisons can be applied successfully. On becoming strong enough to cut into a boll, the worm destroys the contents of one or more bolls. On reaching full size, the bollworm drops to the ground, burrowing usually to a depth of two or three inches below the surface.

Here it remains during the pupal stage, while changing to a moth.

In most parts of the cotton region there are five generations annually produced by the bollworm, the first three of which usually feed on corn. The first and second generations feed on the young leaves in the bud or growing part of the corn plant; the third generation preys chiefly on the ears of corn in the green or roasting-ear condition, when the insect is known as the corn-ear worm or roasting-ear worm. This insect prefers corn to cotton. Hence it remains on corn as long as the ears are green. After the greater part of the corn hardens, usually in July, and after the third and more numerous generation of worms appears, severe injury is done to the squares and bolls of cotton.

### 324. Preventive measures.

In spite of the great injury done to cotton, prevention or poisoning is seldom attempted. Experiments have shown that dusting the plants with a light application of some form of arsenic destroys many of the tiny worms soon after they are hatched and before they are large enough to enter the boll.



*Courtesy U. S. Bureau of Entomology*

**Fig. 124. — Life history of cotton bollworm**

At bottom, larva; in middle, pupæ; at top, adult, or moth.

For poisoning to be most effective, it should begin about the time that adjacent corn ears begin to harden, and it may need to be repeated several times. The poison adheres better if applied while the dew is on the plants.

Another method of reducing the injury to cotton consists in using corn as a trap crop. Occasional rows of corn may be planted late in the cotton field at such times as to bring the corn into the roasting-ear condition about the first of August. Then the moths deposit their eggs on the corn rather than on the cotton plants. The trap crop of corn is still more effective if two plantings are made at intervals of a few weeks, so as to furnish a continual supply of roasting ears during the time when moths are most numerous.

Such corn may be cut and fed to live stock when in the late roasting-ear condition; or it may be left in the field as usual. In this latter case corn is still helpful in reducing the number of bollworms, since it attracts a number of worms to each ear. Here they devour each other, leaving only one or two alive, instead of many.

Plowing in late fall or early winter destroys the burrows in which the insects pass the winter and turns the pupæ up to be killed by unfavorable weather.

**325. Pink bollworm (*Pectinophora gossypiella*).** This pest, in countries where it prevails, as in Egypt and Mexico, is as destructive as is the cotton-boll weevil in the United States. Several outbreaks, arising from the importation of baled cotton or seed from Mexico, occurred in Texas and adjacent regions in the second decade of this century.

However, by prompt burning of every vestige of all cotton plants in and near the infested areas, by stringent quarantine, and by the enactment of state laws creating noncotton zones, this pest appears to have been completely

eradicated before 1923 from the localities into which it had been introduced.

The larva, or small worm, which is at first white, then pink, destroys the seeds within the developing boll and is easily conveyed in cotton seed. In Egypt the means of minimizing the injury from this insect consists in the burning of the old cotton stalks, under a compulsory law.

**326. The cotton caterpillar (*Alabama argillacea*).** Formerly this was the most destructive enemy of the cotton plant. In recent decades the injury has been infrequent and never widespread.

The damage is done by the larval, or caterpillar, stage of a grayish moth. Eggs are laid on the under side of the leaves, where the larvæ hatch and devour the foliage. On reaching the proper degree of maturity the larvæ fold the leaf together and surround themselves with a web in which the pupa, or chrysalis form, of the insect is passed. From the pupa emerges soon the adult moth prepared to lay eggs for a new generation of larvæ. The insect passes the winter as a moth.

Complete protection is afforded by dusting the plants with lead arsenate or calcium arsenate.

**327. The cotton red spider or rust mite (*Tetranychus telurius*).** A discoloration and crumpling of the leaves is often caused by reddish mites, almost microscopic in size. These are found in great numbers, especially on the under side of the leaves. They spread readily and rapidly. If they are discovered before many plants are attacked, the infested individuals should be pulled and burned where they grew.

Treatment is seldom attempted, but sulfur blown on the under side of the leaves has been recommended. Judicious rotation of crops helps to avoid outbreaks of the red spider.

## DISEASES OF COTTON

328. The organism causing cotton wilt (*Neocosmospora vasinfecta*). This disease shows itself at any time after the cotton plants are about 6 inches high. It is prevalent and destructive while they are loaded with blooms and bolls.



Courtesy U. S. Dept. of Agriculture

Fig. 125. — Wilt-resistant varieties of cotton, on both sides of a susceptible kind (in center)

Some of the diseased plants suddenly wilt, and these may die in a few days. Wilting is first shown by the young and tender leaves at the top of the plant. Other diseased plants show a dwarfed unhealthy appearance and may drop their leaves and die, or they may continue to live in an unthrifty condition.

Cotton wilt is caused by a fungous growth, which enters the plant from the soil through the roots. The fungus, or parasitic plant, consists largely of threads which stop up the water-bearing ducts in the roots and stems. The wilting of the leaves is due to the cutting off of their water supply by the plugging up of these ducts with the threads of the fungus.

Cotton wilt may readily be detected by cutting through the main root or stem; the layer just under the bark is blackened, and throughout the stem the cut ends of the stopped-up water-carrying ducts appear as small dark dots (Fig. 126).

**329. Spread and persistence of wilt.** Cotton wilt occurs chiefly in the sandy soils of the southern half of the Cotton Belt. This disease first appears in the field in small spots which enlarge rapidly every year when cotton is planted.

**330. Treatment of wilt by means of rotation of crops.** The most effective treatment of the soil consists in starving the germs. This is done to a considerable extent by keeping cotton out of the field for three years; a longer banishment of cotton still more nearly gets rid of the disease. Meantime the field may be used for corn, oats, grasses, the Iron variety of cowpeas, and certain other plants.

It has been found that cotton wilt is most prevalent on soils which contain not only the germs of the wilt fungus, but also the minute worms that cause root knot (333) on the roots of cotton and of numerous other plants. It is thought that the wounding of the roots of cotton by these tiny worms called *nematodes*, more readily permits



Fig. 126. — Section through wilted (left) and healthy (right) cotton stalks

the entrance of the germs of cotton wilt. Hence, in a field where both troubles occur, no plants should be grown on which nematodes thrive and multiply.

**331. Use of resistant varieties.** Not every cotton plant in a diseased spot dies. The plants that live and thrive



Fig. 127. — A plant of Dixie wilt-resistant variety

are resistant, and the seed saved from them produce plants, the larger number of which are resistant. Thus, by selecting for several generations healthy plants and growing them each year on diseased spots, a variety of wilt-resistant cotton may be bred up (Fig. 127). This can probably be done with many varieties. However, present varieties differ greatly in the degree to which they resist cotton wilt. The varieties Dixie, Toole, and certain others are able to pro-

duce profitable crops in fields that have been ruined for most other varieties by the presence in the soil of the organisms that cause this disease.

To maintain the wilt resistance in these or other varieties, it is advisable to grow seed for planting on infected land and to continue the selection each year from plants that are thrifty. For the main crop, such resistant strains

should be planted on land where nematode worms have been diminished by rotation.

**332. Cotton-root rot (*Phymatotrichum omnivorum*).** This disease, like cotton wilt, causes the sudden wilting of the plants while engaged in forming fruit. However, it is confined to the extreme western part of the Cotton Belt, while cotton wilt is a disease of the southeastern section. Cotton-root rot is especially prevalent on the stiff lime "black waxy" soils of Texas.

It is caused by a fungus that develops threads both within and upon the surface of the roots. Sometimes wartlike bodies appear on the surface.

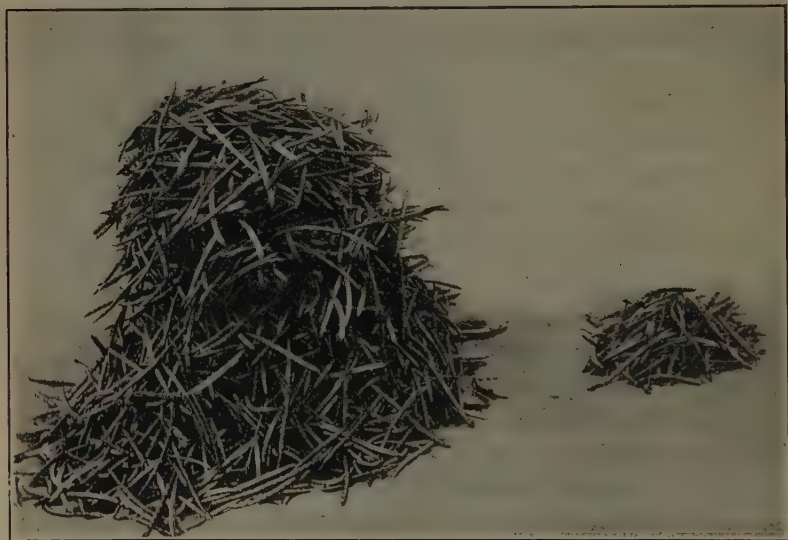


Fig. 128. — Root knot, or nematode injuries, on cotton roots

It has been proved by the Texas Experiment Station (*Bulletin* No. 307) that the organisms causing the disease are carried through the winter on the live roots of cotton and of certain other plants, including wild morning-glory and other perennial weeds. Hence, the destruction of such plants by deep and thorough fall plowing, and otherwise, is recommended, together with rotation of crops. In such a rotation one must avoid the use of other crop plants attacked by this disease; among these are sweet potatoes, alfalfa, most legumes, and most truck crops. On the other hand, all the grains, grasses, and grasslike plants are not subject to root rot. Among other crop plants found by the

Texas Experiment Station to be free from this disease are also the Osceola variety of velvet beans, a newly introduced summer-growing legume, guar (*Cyamopsis tetragonoloba*), tobacco, plants of the melon family, onions; also other members of the lily family.

Through the thorough researches of the Texas investigators Taubenhaus and Killough the control of cotton-root rot now seems possible by means of continued extremely clean fall preparation together with rotation.



Courtesy U. S. Dept. of Agriculture

Fig. 129. — Comparative yield of Iron (left) and Black (right) cowpeas on wilt-infected land in South Carolina

**333. Root knot (*Heterodera radicicola*).** This is a special kind of enlargement on the roots of many plants, caused by the attacks of extremely small worms, called nematodes. Cotton is attacked (Fig. 128), but less severely than are most varieties of cowpeas. The best way to combat this

disease consists in starving the worms, by excluding from the field for two years all plants on the roots of which nematodes can develop, including ordinary varieties of cowpeas and most other plants having tender succulent roots. Meantime the land may be cropped with any of the grains, or forage grasses, peanuts, velvet beans, or the Iron, Brabham, and Victor varieties of cowpeas may be grown, all of which are practically exempt from attack.

The root-knot enlargements may be distinguished from the beneficial tubercles occurring on the roots of cowpeas and other legumes.

When small, root-knot swellings are generally longer than thick, and the swelling is on *all sides* of the root; while tubercles are always formed on *one side* of the root.

**334. Boll rot,** or anthracnose (*Glomerella gossypii*). This fungus is responsible for the greater part of the rotting of the cotton bolls. In its worst form, which oc-

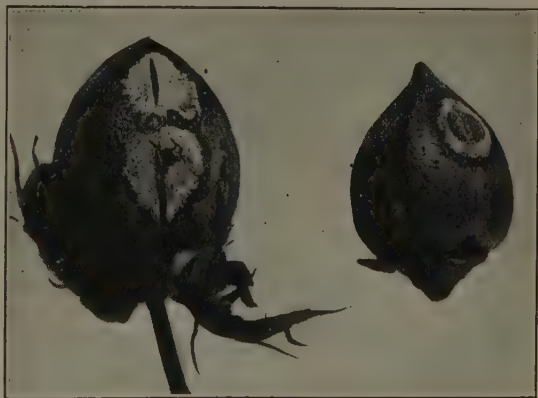


Fig. 130. — Anthracnose, or common boll rot, on cotton bolls

curs during damp weather, small discolored depressions appear on the bolls; these spots become grayish and in time become covered with pinkish spores, which in effect are the seedlike parts of the fungus (Fig. 130). Either a

single lock or the entire contents of the boll may be rotted, or the disease may keep the boll from opening widely.

Dry weather checks the progress of the disease.

Since anthracnose develops most rapidly in the shade, preventive measures include the admission of the maximum amount of sunlight (1) by planting those varieties which



*Courtesy U. S. Dept. of Agriculture*

**Fig. 131. — Cotton seedlings diseased with anthracnose**

have not an excess of foliage and which show partial resistance to the disease; (2) by decreasing the amount of nitrogenous fertilizers which induce a rank growth; and (3) by avoiding very rich bottom land for cotton in regions where boll rot is generally prevalent.

The organism causing boll rot also attacks the young seedlings (Fig. 131), the stem or branches of older plants, and the leaves of cotton.

Anthrachnose is spread by remains of the old plants and

by diseased seed. However, no treatment of the surface of the seed can destroy all of the fungus, since this organism penetrates the parts inside the hull. However, by keeping cotton seed for a period of two or three years before planting the boll-rot organisms are destroyed. The disease may be reduced greatly by picking planting seed only from bolls free from boll rot.

**335. Cotton rust.** This is a name given to several unhealthy conditions of the foliage, which result in yellowing or browning and final dropping of the leaves. This reduces the weight or prevents the maturing of late bolls. It is thought that the fungi associated with most of these leaf troubles are unable to gain entrance into the leaf tissue until unfavorable conditions of weather or soil have weakened the plant. Cotton rust is usually worst in hot weather following a period of heavy rains.

It is much more prevalent on sandy than on clay soil, and on poor than on fertile land. It usually occurs in July, August, and September.

The disease comes on with variable symptoms. When the weather is dry, the leaves of the diseased plants usually



*Courtesy U. S. Dept. of Agriculture*

**Fig. 132.** — Locks of sea-island cotton

Above, fluffy and healthy; below, hard and showing injury by boll rot.

show at first a mottled yellowish color. After wet weather there may be no yellowing but a sudden blackening, dying, and falling of the foliage.

No remedies can be employed after cotton rust appears. Prevention, instead of cure, is needed. Any treatment of the soil and any application of fertilizers that promote a

healthy but not excessive growth of the cotton plant increase its resistance to rust.

On poor soils of any kind the addition of vegetable matter by proper rotation of crops is the most widely applicable means of warding off rust. On very poor sandy soils the application of potash usually enables the plant to resist the disease and to retain the greater part of its foliage

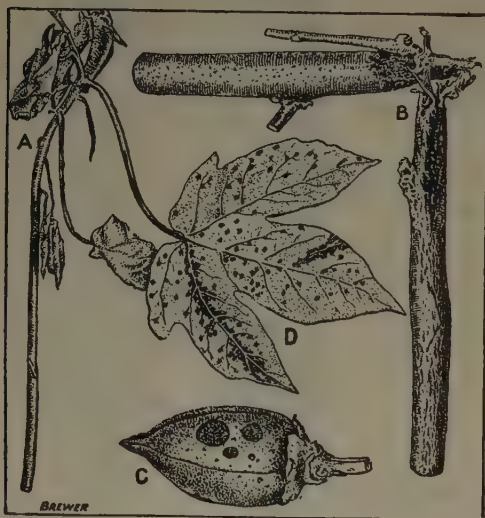


Fig. 133. — Diseased leaves, boll, and stems of the cotton plant

A, B, black arm; C, boll rot; D, angular leaf spot.

until the crop is mature. For this purpose at least 80 or, better, 100 pounds of kainit or 25 pounds of muriate of potash to the acre should be applied in connectoin with the other fertilizers which may be required on that particular soil.

**336. Angular leaf spot (*Bacterium malvacearum*).** This disease is widely prevalent. In its most conspicuous form it causes small angular discolorations on the leaves (Fig. 133), especially of the partly grown plant.

The same organism also causes one form of boll rot and spots on the young seedlings. Both begin as greenish "water-soaked" areas.

The South Carolina Experiment Station (*Bulletin* No. 198) has found that this disease may be prevented by treating the seed with concentrated sulfuric acid (264). The Arizona Station (*Bulletin* No. 90) recommends that the less fuzzy seed of Pima or Egyptian cotton be soaked for one hour in a solution of corrosive sublimate (1 ounce to 7½ gallons of water).

**337. Sore shin, or damping off (*Rhizoctonia*).** The fungus causing this disease penetrates the stem of the very young cotton plants just below the surface of the soil. Some of the diseased plants die, while others recover. It is worse in wet weather. Any method of hastening the drying of the surface soil is believed to be helpful.

### LABORATORY EXERCISES

The laboratory work to accompany this chapter should consist, as far as possible, in getting acquainted with the appearance of any of the insects or diseases mentioned that can be found. If none is present, the time may be occupied in looking up these insects and diseases in bulletins or textbooks dealing at length with one or more of them.

### ADVANCED TOPIC

A detailed library study of any one or more of the insects or diseases mentioned that is responsible for the greatest amount of damage in your county.

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PART III  
VARIOUS FIELD CROPS



## CHAPTER XXI

### PEANUT (*Arachis hypogæa*)

Peanut growing as an important industry in the United States was confined, until the early part of the present century, to the seacoast regions of Virginia and North Carolina and to a small part of Tennessee. However, in recent decades the advance of the boll weevil has caused farmers throughout the Coastal Plain region to turn to peanuts as a partial substitute for the loss of cotton. The total yield of peanuts in the United States increased from about 14,000,000 bushels in 1905 to about 53,000,000 in 1917, while it was about 31,000,000 bushels in 1921. In the early twenties the states leading in acreage and production were Alabama, Georgia, and Texas respectively. The large-scale culture of peanuts is confined to the Cotton Belt.

The peanut is a tropical plant that is widely grown in Asia and Africa. Europe and the United States sometimes import from these continents.

**338. Description.** The peanut is an annual plant, making its growth in the warm season, and it is easily killed by frost. It belongs to the pea family (Leguminosæ) and like other legumes its roots bear numerous tubercles through which the plant is able to draw its nitrogen from the air.

Each plant bears a number of branches, which in the runner varieties lie flat upon the ground, while in the bunch varieties the branches are erect. Each leaf consists of four leaflets (Fig. 134), which have the interesting habit of folding together at night or while rain is falling.

The peanut plant is peculiar in bearing its seeds underground. The flowers are of two kinds, the yellowish, or staminate, and the inconspicuous pistillate flowers. It is only from the latter that nuts, which in this case are true seeds, or peas, develop. Its flower stem, after self-fertilization has occurred, elongates and turns downward; the tip of the pistil, which is sharp, grows into the ground, where it enlarges and becomes the pod (Fig. 134) containing from one to three or sometimes even as many as four seeds.



*Courtesy U. S. Dept. of Agriculture*

Fig. 134. — A peanut plant showing a needle, or peg, with tip enlarging into a pod

**339. Composition.** The following table shows that all parts of the peanut plant are rich in nutritive qualities:

TABLE XIII. COMPOSITION OF THE PEANUT PLANT

PEANUT	WATER (Per cent)	PROTEIN (Per cent)	FIBER (Per cent)	NITROGEN- FREE EXTRACT (Per cent)	FAT (Per cent)
Peanut with hull . . .	6.60	23.20	18.40	14.20	35.00
Peanut kernels . . .	7.85	29.47	4.29	14.27	49.20
Peanut hay . . .	7.83	11.75	22.11	46.95	1.84
Peanut hulls . . .	12.94	7.22	67.29	19.42	2.68
Peanut meal or cake . .	10.74	52.49	5.93	27.26	8.84
Whole pressed peanuts <sup>1</sup> .	7.98	35.49	21.94	21.16	9.03

<sup>1</sup> Containing hulls, usually ground and often sold as peanut meal; analysis from Texas Experiment Station, *Bulletin* No. 203.

A crop of 60 bushels of peanuts to the acre, together with one ton of hay, has been found to contain approximately 85 pounds of nitrogen, 15 pounds of phosphoric acid, 32 pounds of potash, and 46 pounds of lime. Most of the lime and potash is contained in the hay, while the greater part of the phosphoric acid and more than half of the nitrogen are found in the nuts.

**340. Soils.** A sandy or sandy-loam soil is preferred. Peanuts of the highest market quality, that is, with the brightest hulls, are produced on light-colored sandy soil. Red or dark soils, especially when containing much clay, stain the hulls, and hence reduce the market price. Such soils, however, are fully as good for peanuts that are to be consumed on the farm. While a stiff soil is usually avoided for peanuts — partly because of the staining of the shells and partly because peanuts can not be grazed by live stock on such soils while wet — yet these heavier soils sometimes make larger yields than do very sandy fields.

In the choice of soils for peanuts it must be constantly remembered that a loose friable condition of the surface layer is necessary in order that the "pegs," from which the pods will develop, may enter the soil easily.

**341. Liming soils.** A considerable amount of lime in the soil increases the yield. However, the percentage of lime in the soils of the eastern peanut region is low, so that this element is usually supplied artificially. The absence of lime is generally believed to be one of the causes leading to a large proportion of "pops," that is, shells without kernels. Potash is said to reduce the number of "pops." Probably one of the good effects of lime is that of making available the potash in the soil. On soils extremely deficient in lime, as are most light-colored sandy soils, an application of lime is usually advantageous.

**342. Fertilizers.** Other fertilizers for peanuts should be placed in the drill, though some farmers in Virginia apply a few hundred pounds of land plaster to the acre after the plants have made considerable growth. It seems to be better practice, instead of using plaster, to increase the amount of acid phosphate, since nearly half of the weight of acid phosphate consists of land plaster. In either form, the plaster converts a part of the potash of the soil into a more available form.

The fertilizer most generally needed by peanuts is a mixture of acid phosphate and some form of potash, such as kainit or muriate of potash. A good general fertilizer is at least 200 pounds of acid phosphate and 50 pounds of muriate of potash to the acre.

If the land is extremely poor, there is some advantage in using a small amount of nitrogenous fertilizer, so as to promote the early growth of the plant before it is able to draw its nitrogen from the air. For this purpose about 40 pounds of nitrate of soda to the acre may be placed in the furrow at the time of planting or, better still, applied on one side of each row of plants at the first cultivation. The later application of nitrate has the advantage of not stimulating the growth of weeds and grass as early in the season as would be the case if it were applied at or before planting.

However, for the greater part of the supply of nitrogen reliance must be placed on that drawn from the air by the tubercles, or nodules, on the roots of the peanut plant.

**343. Preparation of the land.** The first step in preparing peanut land is to remove any coarse litter, such as stalks of corn or cotton, which might interfere with germination and cultivation. The land should be plowed and thoroughly harrowed. Furrows are opened at regular intervals and in these the fertilizer is drilled, generally by the use of a

machine. When planting on ridges is to be practiced, the land is next ridged, either by means of turnplows, cultivators with suitable points, or by special implements. These ridges, just before planting, should be pulled down partially by harrowing.

**344. Method of planting.** The seeds, usually hulled, are then planted by hand or by means of a planter, which opens, drops, and covers, all at one time. The depth generally preferred is about two inches. On very dry soils, especially when planting is late, a somewhat greater depth and also planting without ridging may be advisable.

**345. Distance between rows and between plants.** With the Spanish peanuts or other erect varieties, the distance between rows is usually 24 to 30 inches, and from 30 to 36 inches with the running kind. Spanish peanuts on good land may be planted advantageously as close as 4 inches apart in the drill, but cultivation is more economical if more space is given, usually 8 to 12 inches between hills, with two peas in a place. In experiments at the Arkansas Experiment Station the yield of Spanish peanuts decreased as the space between rows was made wider than 2 feet and as the distance between plants was increased above 6 inches.

**346. Seed.** To plant an acre of either Spanish or running peanuts rather thickly requires about two bushels of unhulled or about half a bushel of hulled peanuts.

The seed intended for planting should be harvested before the plants are killed by frost and so stacked and stored as to avoid heating. Varieties having large pods require the shelling of the seed peas, but shelling is not necessary with the Spanish variety. The latter is usually merely broken, each piece being planted with the inclosing hull. In this case, some growers find it advantageous to soak unhulled Spanish peanuts for a day before planting them in moist soil.

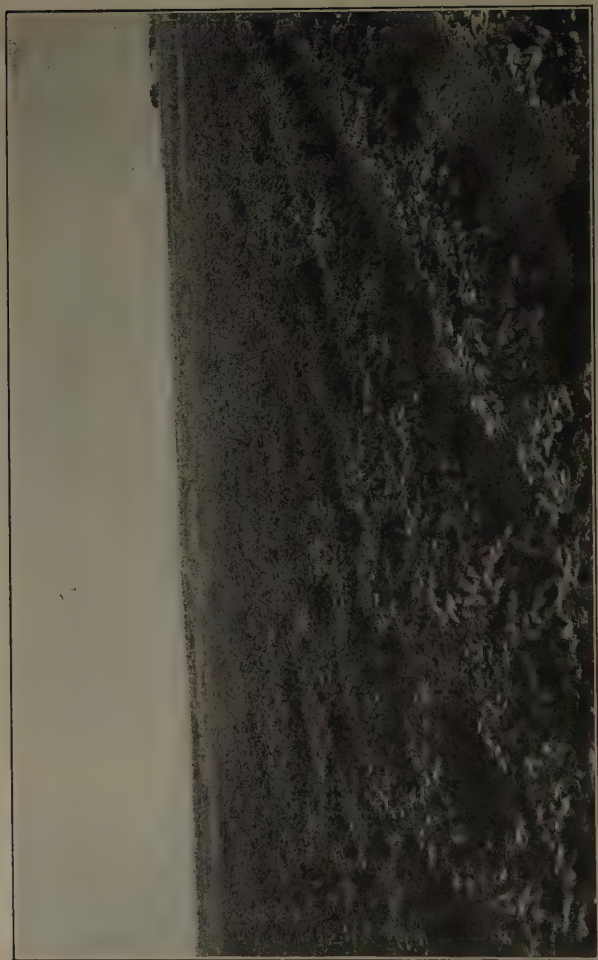


Fig. 135. — A peanut field

Shelling results in more rapid germination and a better stand. For large-scale planting shelling is done by machinery, which is less expensive but affords a poorer stand, especially if the hulled peanuts are kept for weeks before planting.

**347. Time of planting.** The time of planting varies greatly with the latitude. In Virginia the greater part of the crop is planted in May, and this is the preferred month for planting the running varieties throughout most of the Cotton Belt. However, further south these varieties are often planted in April. The Spanish peanut requires less than four months for maturing a crop. Hence, this kind can be planted at any date desired after cotton comes up, and up to the first of July. Even later plantings of this variety are sometimes made, but at the sacrifice of yield. Spanish peanuts can be planted after any of the small grains are harvested; but unless the season is especially favorable, maximum yields are not to be expected where grain stubble is plowed under in June, because of the tendency of such fields to dry out or otherwise get into poor mechanical condition.

**348. Tillage.** After planting and before the plants appear above ground, the peanut field may be tilled with a weeder. As soon as the line of plants can be seen, tillage begins with some form of cultivator equipped with fine teeth or with scrapes. After the young plants have attained some degree of toughness, the weeder is brought into use at frequent intervals. It is best run diagonally across the rows. By this means much of the young grass along the line of the drill is destroyed, thus saving much work with the hoe. One hoeing, or, if necessary, a second one is given, but only when needed. Grass growing among the prostrate branches of the running varieties should be

pulled by hand; large weeds in such positions are better cut off, since the pulling of large grass or weeds, after peanuts form, disturbs the buried pods and does more harm than good.

The cultivator is used as often as necessary. The first cultivation may be rather deep. Unless level culture is practiced, it is customary for the cultivator to throw some earth around and among the plants, thus making a low ridge or bed of loose soil in which the "pegs" may become imbedded.

**349. Rotation.** When the vines of this legume are returned to the land and evenly distributed, or when the crop is "hogged off," that is, grazed on the land by hogs, the soil is enriched, especially in nitrogen. However, few crops are more exhaustive to soil fertility than peanuts grown for market, where both the nuts and vines are removed from the land. Hence, other legumes generally need to be included in rotation with market peanuts.

In the sandy soils of the Coastal Plain, in which peanuts are extensively grown, the organisms causing root knot of cotton and other plants are widespread. Peanut roots are not attacked by these nematode worms. Hence, this crop may there be employed, together with the other resistant plants of the region, such as corn and velvet beans, as a means of starving the nematode worms, thereby avoiding severe damage from root knot to succeeding crops of cotton and truck. If a wilt-resistant variety of cotton is preceded for two years by peanuts, corn, and velvet beans, injury from cotton wilt, as well as from root knot may be minimized.

One suitable rotation for the conditions just mentioned is the following:

First year: Peanuts.

Second year: Fall-sown oats, followed by a wilt-resistant variety of cowpeas or by peanuts to be "hogged off."

Third year: Corn, with velvet beans.

Fourth year: Cotton.

Spanish peanuts may be grown immediately after the harvesting of an early-maturing small grain but the yield is usually reduced by such late planting.

**350. Varieties.** There are but few varieties of peanuts grown in the United States. The most important are described below (Fig. 136).

*Virginia Runner.* This is a variety having long branches flat on the ground, and bearing pods throughout the entire length. The peas are of light color and usually two or sometimes three in a pod. The pods do not adhere well to the vines in digging. The weight of this and of other large varieties is twenty-two pounds per bushel.

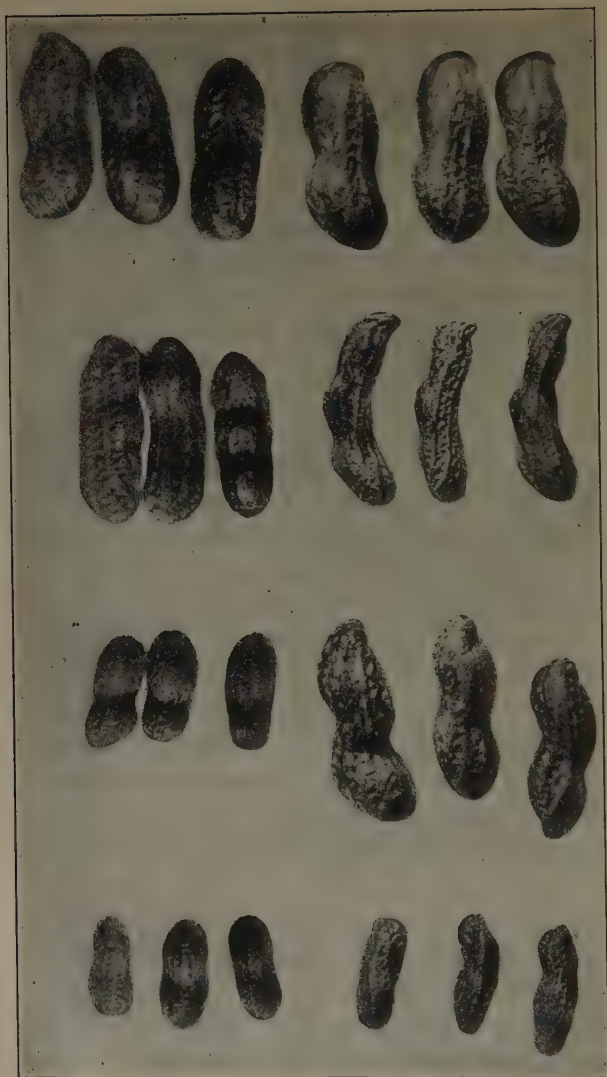
*Virginia Bunch* is an erect variety bearing its fruits only near the base of the plant. The nuts are similar to those of the *Virginia Runner*.

The *North Carolina*, sometimes called the *Wilmington* and sometimes the *African*, has spreading prostrate stems, and the plant is of somewhat smaller size than the *Virginia Runner*. The pods and peas are also smaller than those of the *Virginia Runner*, but larger than Spanish peanuts.

The *Tennessee Red* has pods each containing several peas, reddish in color. The growth is more upright than that of the *Virginia* and *North Carolina Runner* varieties.

The *Valencia* is an upright or bunch plant with pods and peas larger than those of the Spanish.

The *Spanish* is the earliest type of American peanuts. There are at least two varieties, *Red Spanish* and *Improved*, or *White, Spanish*. These are alike except that in the



*Courtesy Alabama Experiment Station*

**Fig. 136. — Eight varieties of peanuts**

On left from top to bottom, Jumbo, Valencia, Red Spanish, White Spanish; on right, Improved Virginia, Tennessee Red, Virginia Bunch, and North Carolina Runner.

latter the thin covering around the "meats" is paler, which results in affording a clearer oil. This quality of White Spanish peanuts, together with the high percentage of meats or hulled peanuts — usually constituting 72 to 75 per cent of the total weight — makes this the favorite variety for milling. The branches of Spanish and other Bunch varieties grow upright, and the pods are clustered around the base of the plant. Hence, in sandy soil practically all the peanuts adhere to the vines when the latter are pulled, after being loosened. The pods are short and slender, usually containing two nuts. The hull lies in close contact with the nut, so that moisture is quickly conveyed to the latter; as a result, Spanish peanuts sprout more quickly, if left in the land after maturing, than do varieties with larger pods and more space between kernel and shell. Hence, Spanish peanuts must be dug or used as hog feed soon after ripening, while the large-podded varieties may remain sound enough for hogs to eat throughout the first half of the winter. The former may be grown on soil containing less lime than is necessary for the best growth of Runner varieties.

**351. The peanut as human food.** The peanut constitutes a most nutritious human food, both in roasted condition and in various manufactured forms, including peanut butter, oil, and confectionery. The pressing of oil from peanuts has long been an important industry in the Old World, where the resulting product was used as a substitute for olive oil. Only since the progress of the cotton-boll weevil has reduced the supply of cotton seed available for crushing have the cotton-oil mills of the South added to their usual output peanut oil and peanut meal.

**352. The peanut and its by-products as food for live stock.** Outside of those regions in which the peanut is

grown as a sale crop, its principal use is as a food for hogs, the hogs doing the harvesting. To make the season in which peanuts are available as long as possible, there should be a succession of plantings of Spanish peanuts at intervals of a few weeks; this succession of Spanish peanuts should be planted in addition to the necessary acreage in the running varieties, the latter being grown largely with a view to use in December. Hogs make satisfactory growth on peanuts alone, but the addition of corn makes growth more rapid and improves the quality of the meat and lard produced. The addition to a peanut diet of a small amount of tankage, rich in ash, makes the gains more economical.

Hogs fed on peanuts make very soft pork and lard that melts at a low temperature. These products are made firmer by removing peanuts from the ration two months before the animals are killed.

The Spanish and other varieties of peanuts having an erect habit of growth produce from  $\frac{3}{4}$  to  $1\frac{1}{2}$  tons of excellent hay to the acre. This should be mowed before many of the leaves fall or become spotted. Hogs may then be turned in to consume the nuts.

Peanut meal is quite similar in composition to cottonseed meal and is suitable for the same uses.

In some regions the entire plants — vines with attached pods — are fed to horses.

**353. Harvesting.** The principal harvesting season is the months of September and October. Peanuts for market or for seed should be dug before frost. They are ready for harvesting as soon as the pods about the base of the plant show a tendency to shed, or easily become detached from the vine. Harvesting may be done in a variety of ways. The usual method is to remove the moldboard from a turnplow and run the share under the row on each side

at a sufficient depth not to sever the pods from the branches.

Sometimes a special blade is attached to the plow in such a way as to run under the line of plants. The plants are then lifted by hand or by means of forks and thrown into small piles on every third row. They are stacked, usually



*Courtesy U. S. Dept. of Agriculture*

**Fig. 137. — Building peanut shocks**

on the same day as dug and before the plants have thoroughly dried. The stacks are as slender as possible and only about five feet high (Fig. 137). They are made around poles seven feet long, driven securely into the ground. The tops are turned outward and the nuts inward, so as to protect the latter from rain, dew, and sunshine, and from the attacks of birds and other animals.

To keep the nuts from resting on the ground, short cross arms are nailed on the lower part of each stacking pole.

Large picking machines constitute the most economical method of removing the nuts from the thoroughly cured vines. Peanuts intended for special market demands, other than milling, are subjected, after being shipped from the farm, to a cleaning or polishing process.

**354. Yields.** The average yield of the entire country is usually below 35 bushels an acre; 60 bushels or more is a good crop. However, the two highest records now known are 172 bushels an acre made at the Arkansas Branch Experiment Station at Newport and 184 bushels (of 28 pounds each) made by J. F. Yarbrough in the extreme southeastern part of Alabama.

**355. Enemies.** The peanut has few enemies either among insects or among the minute organisms usually concerned in the diseases of plants.

The most common disease is a form of leaf spot (*Cercospora personata*). The symptoms are the appearance of brownish spots on the leaves. This disease is more frequently noted on sour or poorly drained land. If it appears late in the life of the plant, it will often be practicable to mow the erect varieties for hay before the disease has rendered the vines unfit for this use.

In a few localities, especially around old premises, the peanut plant is sometimes killed by a form of root rot produced by a fungus (*Fusarium*). The symptoms are the presence of a mass of white threads on the stem just below the surface, together with the appearance of minute round, whitish, or brownish bodies, about the size of mustard seeds, clustered around the stem, close to the surface of the ground.

Doubtless rotation of crops, keeping off the infected fields most of the legumes and other susceptible crops, is the best means of avoiding injury by this disease.

### LABORATORY EXERCISES

(1) Determine the weight of 100 shelled nuts of the Spanish and of some larger variety.

(2) Determine the percentage of hulls in the unshelled dry nuts of both the Spanish and some larger variety.

(3) If growing peanut plants are available, make a drawing showing where the "pegs," or "needles," originate, and the enlargement which they undergo after penetrating the soil.

(4) The principal laboratory work to accompany this chapter should be the actual performance or observation of the field operations herein discussed.

### ADVANCED TOPICS

A. A library study of the statistics, by states and by decades, of American peanut production.

B. A field study of the peanut plant and of all available varieties.

C. A library study of recorded yields and oil content of varieties, and of results of fertilizer and culture tests at Southern Experiment Stations.

D. The grading of commercial samples of peanuts. Use at least pint samples of "farmers' stock," that is, of peanuts that have never been through a peanut cleaning factory.

Delicate scales are necessary. Use the score card on page 334 or some official substitute.

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### TENTATIVE GRADES FOR WHITE SPANISH PEANUTS

(Figures express percentages *by weight*, taking as 100 the weight of the entire sample of unhulled peanuts.)

	RE- QUIRE- MENT <sup>2</sup>	GRADES <sup>1</sup>	RECORD OF LETTERED SAMPLES GRADED BY STUDENT			
			A	B	C	D
	<i>Per cent</i>		<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Sound kernels, at least . . .	70	No. 1				
Sound kernels, at least . . .	65	No. 2				
Sound kernels, at least . . .	60	No. 3				
Permissible defects:						
(a) kernels previously shelled, not more than . . . . .	2	All				
(b) unshelled pod having black or moldy hulls, not more than . . .	10	All				
(c) Mixture of other va- rieties, not more than . . . . .	1	All				
(d) Damaged kernels, not more than . . . .	3	All				
Grade of each sample as de- termined by student . . .			No. (?)	No. (?)	No. (?)	No. (?)

<sup>1</sup> The term “Sample Grade” designates the quality of any lot of peanuts not meeting the requirements of any one of the numbered grades, and such peanuts should be sold only after the buyer has inspected the sample.

<sup>2</sup> Peanuts of any numbered grade must be mature and dry. The required percentages of shelled peanuts are lower for large-pod varieties than for Spanish peanuts.

## CHAPTER XXII

### SUGAR CANE (*Saccharum officinarum*)

Sugar cane is one of the family of the grasses. Like all the grasses, sugar cane has a jointed stem with a leaf originating at each node. The leaves are arranged in two vertical ranks and are borne alternately on two sides of the stalk. The plant grows to a height of 8 to 12 feet, and, in tropical countries, to a greater height.

The stem is large and upright, except when bent or reclined by wind or by its own weight. A number of stalks usually grow together in a cluster, due to the fact that this plant throws up additional stems from the buds at its lower nodes below the surface of the ground.

**356. Duration.** Sugar cane is perennial. In some tropical countries a number of harvests are secured from a single planting. In Louisiana usually only two or three crops are grown before the stubble becomes too thin to produce profitable yields. In the pine belt east of Louisiana and north of the latitude of Florida, a planting of sugar cane usually affords but a single crop, annual planting being necessary. In this region the cane is usually cut and made into sirup within eight months after the date of planting. In tropical countries the plants are often permitted to grow for fourteen months or more before being harvested.

**357. Leaves.** The leaves of sugar cane are broad and long, sometimes reaching a length of three feet. In some varieties minute prickles occur on the leaves, making the harvesting of the crop disagreeable. The leaves have a central midrib,

which gives a moderate degree of stiffness to the lower part of the leaf blade.

The leaf of the sugar cane, like that of corn, has special cells which, when the supply of water is not sufficient, roll it together, thus reducing the loss of moisture. The leaf sheath, or part that folds around the stem, serves to protect the bud, or eye, which it incloses. As the plant matures, the leaves unclasp from the stem and hang loosely or fall. The falling of any leaf is regarded as an indication of the maturity of the internode next below this leaf.

In the cells of the leaves the green coloring matter during daylight manufactures starch from the carbonic acid gas of the air and the water brought from the roots. This starch is then changed and conveyed to all parts of the plant, a large part of it being finally deposited in the pith cells of the stem in the form of sugar. Thus, sugar, the valuable product of cane, is made up almost entirely of water and of a gas occurring in abundance in the air; if only sugar were removed from the land there would be practically no exhaustion of the plant food by the growing of sugar cane.

**358. Roots.** A small part of the main stem of cane is below the surface of the ground, connected below either with the cane that was planted or with another cane, from one bud of which it grew. The nodes, and hence the buds, on this underground part of the stem are very close together, making it possible for a number of stems to spring up in a cluster, or stool, as the result of the growth of these underground buds into suckers, or young canes. In a band around the stalk at each node are a number of nearly transparent dots. From these dots spring true roots when this joint is kept moist by contact with the soil. The roots are fibrous and usually they do not penetrate to great depth.

**359. The stem.** The part most valued is the stem, from which sugar and sirup are manufactured. The stem is large and cylindrical and consists of a series of internodes of variable length, separated by joints, or nodes (Fig. 138). The internodes (often popularly called "joints") are short at the base and longer toward the middle or upper part of the stalk. The length of internodes varies greatly with different varieties and is decreased by drought, or by other condition unfavorable to growth. The rind, or outer portion, of the stalk consists chiefly of strong fibrous tissue, giving strength and hardness to the stem. The rind, and hence the stalk, is of various colors, depending on the variety. Among the most common colors are purple (or reddish), striped purple and white, and green. Yellow, white, brown, and other colors also occur, especially in varieties grown in tropical countries.

On cutting across a stalk of cane, one finds the greater part of the space within the rind occupied by white pith cells. It is within these white pith cells that the sugar is contained. The enormous pressure of a mill is required to expel the juice in which the sugar is dissolved. At intervals among these pith cells may be found strands of tougher tissue running parallel to the length of the stalk. These tough strong strands are the bundles of fibrous tissue that serve for the circulation of liquids within the plant.

The internodes are longer where all conditions are favorable to a luxuriant growth.

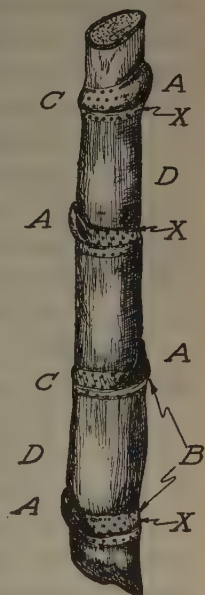


Fig. 138. — Part of a stem of sugar cane

A, buds, or eyes; B, joints; C, nodes; D, internodes; X, dots where roots may originate.

**360. The buds, or eyes.** At each node on the stem is borne a bud. This is the part of the plant from which the next crop must grow, just as the eye of the Irish potato serves instead of seed to perpetuate that plant. The buds occur alternately on opposite sides of the stem. A bud is about the size of half of a pea. It is closely enfolded and protected by the leaf sheath. Moreover, each bud consists of the inner part, which is capable of growth, and of several outer protecting coats.

The aim in harvesting before frost that part of the cane crop intended for planting and the banking or windrowing of cane in winter is to protect the buds from freezing.

**361. Method of propagation.** For commercial purposes, the only method of propagating sugar cane consists in planting the stalks or sections of stalks on which are borne the eyes. Stimulated by the moisture and heat of the soil, the bud swells and grows into a sucker, or young cane. This develops a stalk with buds at each node. The growth of clusters of stalks results from the growth of several of the buds on the base of the young plant, usually from those nodes located below the surface of the ground. Thus, a cluster or stool consists of stalks of various sizes and ages, only one of which grew from the planted bud, but all indirectly tracing back to that bud. The percentage of the eyes of planted cane capable of growth varies greatly with different varieties and is not the same for the buds growing on the upper and lower part of the stalk. Care in planting results in an increase in the number of buds that grow, thus affording a thicker stand. The young sucker draws its nourishment from the mother stalk (planted cane or older growing plant) until its own roots have developed sufficiently to supply it with the necessary food and moisture.

**362. Propagation of sugar cane from seed.** In tropical countries some varieties of sugar cane *arrow*, or produce from the top of the stem, when a little more than a year old, a flower stalk, on the top of which is borne a silky head consisting of innumerable very small flowers. Each flower when mature resembles a small chaffy grass seed. Until the latter part of the nineteenth century it was thought that no seed reached such a degree of development as to be capable of germination and growth. However, scientists have now learned methods by which a very small proportion of the seeds of sugar cane produced in tropical countries may be made to grow. The plants produced by seed grow very slowly, requiring several years to attain the size that is ordinarily reached in a few months by cane propagated from buds.

**363. Improvement of cane.** It has been proved that sugar canes propagated from buds differ among themselves in the percentage of sugar and in other useful qualities. It has also been found that the selection for planting purposes of canes from clumps or stools the stalks of which are rich in sugar results in an improvement in the quality of the next crop. By this mode of selecting good stalks, some improvement can be made in sugar cane.

An experiment conducted at the Louisiana Sugar Experiment Station through six generations showed a decrease in yield from the repeated planting of small canes. Taking the average for all years the continuous planting of large canes produced an average crop of 30 tons of cane to the acre. The repeated planting of medium-sized canes yielded 29.85 tons; and the continuous planting of small canes afforded an average crop of only 25.95 tons of cane to the acre. The decrease from using small seed canes was greater in the first crop, or "plant cane," than in the second crop, or "stubble cane."

However, it is a general rule that plants grown from seed show greater differences among themselves than do the same kinds of plants when propagated from buds. Taking advantage of this, selection is made of those seedling canes which show especially desirable qualities, and these strains are thereafter propagated by planting the canes in the usual way, thus retaining and perpetuating the quality desired. The planting of true seed is now the first step in the usual method of bringing into existence new varieties of sugar cane.

### COMPOSITION

**364. Proportion of parts of the cane.** At the Louisiana Sugar Station, for each ton of stripped cane of the Red, or Purple, variety there was found about three quarters of a ton of tops, leaves, and roots. Nearly 90 per cent of the weight of the stripped cane may consist of juice. However, the small mills having only three rollers usually extract only about half of the total juice.

The large and powerful mills connected with sugarhouses extract from 75 to 80 per cent of the weight of the cane as juice.

A ton of stripped cane is expected to yield between 150 and 180 pounds of sugar. Exact data for the yield of sirup are not abundant, but the output may be estimated roughly at 12 to 15 gallons a ton of stripped cane crushed in small poor mills, or as much as 22 gallons in good mills in Louisiana.

**365. Relative composition of sugar cane in the sugar belt and in the coastal pine belt.** The sandy uplands of the coastal pine belt of the United States afford a cane fully as rich in sucrose, or crystallizable sugar, as the canes of Louisiana, the sucrose usually ranging from 10.50 to 14 per cent. But the shorter season in the pine belt makes

the percentage of glucose, or noncrystallizable sugar, greater here than in Louisiana. This higher glucose content would be a great disadvantage in manufacturing sugar, since glucose not only fails to crystallize, but its presence also causes some of the sucrose to fail to make sugar.

On the other hand, this high percentage of glucose is a positive advantage in sirup making, because the greater the amount of this substance the smaller is the tendency for the sirup to crystallize, or to turn to sugar — a change that is extremely undesirable.

**366. Removal of plant food from the land.** At the Louisiana Sugar Station (*Bulletin* No. 59) the following facts were learned as to the amount of plant food removed by a ton of stripped Red, or Purple, cane with the accompanying waste parts:

TABLE XIV. PLANT FOOD REMOVED FROM LAND BY SUGAR CANE

	POUNDS PER TON OF STRIPPED CANE		
	Nitrogen	Phosphoric Acid	Potash
In 1 ton of stripped canes . . . . .	1.08	1.04	1.22
In leaves and tops (1376 lb.) . . . . .	1.73	0.49	1.21
Total in cane, leaves, and tops . . . . .	2.81	1.53	2.43

In Louisiana the tops and leaves are usually burned on the land, thus saving their quota of phosphoric acid and potash, but losing all the nitrogen. Under these conditions the loss of plant food represented by a crop of 25 tons to the acre of stripped cane would be

Nitrogen. . . . .	70 pounds
Phosphoric acid . . . . .	26 pounds
Potash. . . . .	30 pounds

When the leaves and tops are burned, sugar cane is an exhausting crop. It makes a demand for a large proportion of nitrogen in the fertilizer, or else for much nitrogen supplied by growing a preceding crop of cowpeas or velvet beans. Some analyses of cane grown in Hawaii and in foreign countries show a larger draft on the fertility of the soil than is indicated by the analyses of American cane.

### SOILS AND FERTILIZERS

**367. Soils.** The sugar cane bears a large number of broad leaves and presents a very extensive surface engaged in transpiring water. Hence, the most important requirement in a soil for sugar cane is that it afford a generous supply of moisture throughout the growing season. W. C. Stubbs says that the best soil for sugar cane should be capable of holding 25 per cent of its weight of moisture.

In a hilly country alluvial bottoms make the best soil for sugar cane, provided they are well drained, and the soil somewhat sandy, but fertile. Especially in the northern part of the region where sugar cane is grown, a stiff or poorly drained soil is unsuitable for this plant. On such soils, the yield of cane and the quality of the sirup are unsatisfactory.

Soils for sugar cane should be fertile and well supplied with vegetable matter.

Stubbs states that the soils of the sugar belt of Louisiana contain on an average

Lime . . . . .	0.5 per cent
Potash . . . . .	0.4 per cent
Phosphoric acid . . . . .	0.1 per cent

He calculates that if the entire growth were removed from the land, a soil of this composition contains enough

of the above fertilizer constituents for the following number of crops, each of 25 tons of cane, besides tops and leaves:

Nitrogen for . . . . .	70 crops
Phosphoric acid for . . . . .	150 crops
Potash for . . . . .	333 crops
Lime for . . . . .	1250 crops

As a matter of fact, the yield would decline to an unprofitable amount long before any one form of plant food would be completely exhausted.

**368. Uplands for cane.** Most of the uplands on which sugar cane is sometimes grown east of the Mississippi River are much more sandy and hence much more deficient in plant food than the soils of the sugar belt of Louisiana. Therefore, on such upland the yield of cane to the acre is usually lighter. However, there is partial compensation in the fact that cane grown on the pine lands is ordinarily richer in total sugars than cane grown on the alluvial lands in Louisiana.

**369. Fertilizers.** Under the system generally practiced in Louisiana, the tops and leaves are annually burned on the field, thus returning to the soil a part of the phosphoric acid and potash, but robbing the soil of practically all the nitrogen contained in the above-ground part of the plant. Therefore, the principal fertilizer constituent needed is nitrogen. Experiments at the Louisiana Sugar Station have indicated that as much as 48 pounds of nitrogen and 36 pounds of phosphoric acid to the acre may be applied with profit; and that cane grown on the soils of the sugar belt need but little, if any, potash. No fertilizer was found to influence notably the percentage of sugar in the juice, when the fertilizer was used in moderation on rich alluvial soils.

Part of the commercial fertilizer is applied advanta-

geously before the planting of the cane, and a part may be reserved for application soon after growth begins. If nitrogenous fertilizer is applied too late in the summer, it delays the ripening of the cane and hence reduces the yield of sugar or injures the quality of sirup. Phosphates tend to hasten the ripening of cane, as also of other plants.

**370. Sources of nitrogen.** The demands for a large amount of nitrogen are met by the planters of Louisiana by plowing under, every third or fourth year, a luxuriant growth of cowpeas, usually grown in the corn in rotation with sugar cane. In the pine belt east of the Mississippi River nitrogen should be supplied by plowing under, the year before planting cane, a luxuriant growth of velvet beans or of a wilt-resistant variety of cowpeas (Fig. 129).

Nitrate of soda, sulfate of ammonia, and dried blood have proved suitable sources of nitrogen.

**371. Summary regarding fertilization of cane.** On soil not previously enriched, sugar cane requires a fertilizer rich in nitrogen. Potash is needed on the sandier lands. Phosphoric acid should generally be supplied, but acid phosphate need not constitute so large a proportion of the fertilizer for cane as for cotton.

## CULTURAL METHODS

**372. Propagating material.** Sugar cane is propagated by planting the stripped stalk, from the buds, or eyes, of which grow suckers. In the sugar belt the stubble of cane lives through the winter, so that there cane is usually grown two or three years in succession from a single planting. In the tropics one planting serves for many years.

In the greater part of the American sirup belt, the stubble is so often killed that a good stand from this source is not expected. Yet at least as far north as Montgomery, Ala-

bama, a small portion of the stubble lives through the winter, and this amount can be increased by plowing two furrows over the stubble before killing frosts occur in the fall. In this region the plants grown from stubble cane are usually small and short-jointed. Hence, stubble cane here is usually not ground but is used as seed material for the next crop.

**373. Preparation of the land in Louisiana.** A crop of cowpeas grown with corn is plowed under with four-, six-, or eight-horse plows in August or September. Since the cane fields are flat and wet, drainage is here most important. To improve the drainage, the land is thrown into high beds early in the fall, and about a month after the land was first plowed. These beds are usually 5 to 7 feet wide. Plowing is deep. Water furrows are opened with a double moldboard plow, as an additional step in draining the land.

Throughout the season these beds are kept high and the water furrows open. Better to facilitate drainage, "quarter drains" are run across the rows at suitable intervals at a depth of about six inches below the level of the water furrows. These "quarter drains" empty into narrow deep ditches, which are about 100 or 125 feet apart and parallel to the rows of cane. Tile drains are in many respects preferable to open ditches, but in the sugar belt they are liable to become stopped by sediment deposited when water is backed up in them.

**374. Planting in Louisiana.** In the top of each bed a furrow is opened with a double moldboard plow, the bottom of which should not be as deep as the water furrow. In this newly opened trench is planted a double row of cane. The amount of "seed" required by this method of planting is about four tons to the acre. The cane is then covered by the use of a disk cultivator. Fall-planted cane is cov-

ered with a considerable depth of earth as a protection from cold in winter.

In Louisiana planting begins as early in the fall as the cane reaches sufficient maturity for the buds to germinate. It continues at least until the grinding season begins in November, when the laborers and teams are needed for the cutting and hauling of the crop. Whatever areas are not planted in the fall or early winter are planted in February or March, cane that has been protected throughout the winter in windrows being used.

Fall planting is usually considered better than spring planting, the former affording an earlier growth and a larger harvest. In Louisiana the entire uncut stalk is used for seed. In some warm countries the tops are planted as soon as cut; thus that part of the plant which is of least value for sugar making is utilized.

**375. Planting in the pine belt.** The land is plowed into beds 5 or 6 feet wide. In the water furrow is strewn commercial fertilizer, or cotton seed. Where much fertilizer is used, a furrow should be made through it, so as to mix it with the soil, thus preventing the eyes of the cane from coming into immediate contact with the fertilizer; this is because the buds may be killed by contact with certain fertilizers. A single line of cane, the ends of the stalks slightly overlapping, is then planted in the water furrow. The cane is covered and a list, or bed, formed above it. This covers the cane so deeply that it is desirable to remove a part of the soil by harrowing before the young plants come up.

Planting is done chiefly in the first half of March, but in parts of Florida fall planting is sometimes practiced.

**376. Tillage.** In Louisiana in the spring a part of the soil is removed with the hoe from above the fall-planted

cane and the row barred off and fertilized. Then the soil is thrown toward the rows. Subsequent tillage is effected chiefly by the use of a disk cultivator, supplemented by some other suitable implement in the middles, or water furrows, which must be kept open continuously to afford drainage.

In the sandy lands the more common implements of tillage are the scrape and various styles of one-horse cultivators. Frequent cultivations and occasional hoeings are given up to the time when the cane affords shade enough to keep down weeds and grass. After the first one or two cultivations, the depth should be shallow. On well-drained soils in the pine belt, there is not the same necessity as in the sugar belt for making the beds high.

In Louisiana when a crop is grown from the stubble, the dried tops and leaves of the preceding crop are burned in winter; the first tilling then consists in loosening the soil with the *stubble digger*. Previous to this, any stubble on which the upper eyes have been injured is cut off below the surface of the ground by the *stubble shaver*. Fertilizer is applied in a furrow near the line of stubble, and the soil is then thrown towards the row.

W. C. Stubbs thus describes the usual steps in the cultivation of sugar cane in Louisiana: "As soon as a stand is secured in either plant or stubble cane, the dirt is returned and the middles split out with a two-horse plow and the latter then sent to the tool room to remain until the next season. The first cultivation is made by straddling the cane with the disk cultivator, using three unequal disks, running them very shallow and throwing very little dirt to the cane. The middle or diamond cultivator follows, working completely the middle of the row. In this operation, both mules walk between the cane.

"The next cultivation is made in the same way, or if the cane has grown considerably and requires more dirt, the three unequal disks are removed and two or three of equal size are substituted. These disks can be dished to throw much or little dirt. Having displaced the three unequal disks with those of equal size, the cultivation continues with them, followed immediately by the diamond or middle cultivator until 'lay by' is desired. Then a single large disk is substituted on either side for the smaller equal ones on the disk cultivator, and the two forward shovels on the middle cultivator are turned up, leaving only three for work, and with these the cane is laid by."

**377. Burning.** The burning of the dried tops and leaves results in the loss of all the nitrogen, but it is considered advisable in the sugar belt of Louisiana as a means (1) of destroying many cane borers; (2) of causing the land to dry out more rapidly than if the litter were left on it; and (3) of disposing of the unrotted vegetable matter that would interfere with cultivation.

**378. Rotations for sugar cane.** A common rotation in Louisiana is the following:

First year: Corn, with broadcast cowpeas sown as early as practicable at the rate of one to three bushels to the acre.

Second year: Sugar cane from planted canes.

Third year: Sugar cane from the old stubble. If the stand of stubble is good and the land very rich, a third crop of sugar cane may be harvested, this also springing from the old stubble.

The Louisiana Sugar Experiment Station found that when the entire growth of cowpeas was plowed under as usual, the subsequent yield was larger by 7.4 tons of cane to the acre than where only the stubble of the cowpeas was used as fertilizer. The sowing of annual yellow melilotus

in the fall between the rows of cane resulted in an average increase of about 4 tons of cane an acre.

As a means of minimizing root rot, a four-year rotation is recommended, including only two years of cane.

In the pine belt north of Florida annual planting of sugar cane is generally necessary. Here this crop should usually be preceded by velvet beans plowed under for fertilizer. Since the sugar-cane plant is attacked by nematode worms, it should not be grown on infested soil, or it should be preceded on such soils by a resistant plant, such as velvet beans.

### VARIETIES

**379. Standard varieties.** By far the most popular variety in the pine belt is the Purple, or Red, cane. The Striped, or true Ribbon, cane is used to a limited extent. For sale in the local markets for chewing, the Green variety is most popular, and the single stalks of this usually sell at about double the price of other kinds. Green cane is but little used for sirup making (1) because this variety matures later than Purple cane and the yield of sirup is believed to be less; (2) because Green cane is more easily injured while in the seed bed; and (3) because it is regarded as less able to withstand drought.

**380. Other varieties.** In the sugar belt Red or Purple cane and Striped cane are the standard kinds. In recent years two seedling canes, D 74 and D 95, introduced by the Louisiana Experiment Station, have been extensively grown in that state. Both of these have afforded larger yields, a greater percentage of crystallizable sugar, and higher purity than the ordinary Purple cane.

D 74 is a tall, erect, green cane, with long joints, and a deep green foliage. It suckers abundantly and produces large stalks and heavy yields.

D 95 is a large, erect, purple cane. It has long joints, large stalks, and pale green foliage; it suckers well and is fully as hardy to cold as ordinary Purple cane; but it is very susceptible to the mosaic disease.

Both of these are upright in growth, which facilitates harvesting, and both have made larger yields than Purple cane.

A still later introduction is L 511. This is valued because of its ability to grow without serious injury from the mosaic disease.

The Louisiana Experiment Station made many field and sugarhouse tests, comparing Red (or Purple) with Striped cane. The Striped cane had the following advantages: The stalks grew slightly larger, affording a large yield of cane; the stalks were softer and somewhat more easily crushed and manufactured into sugar.

The Red or Purple cane was hardier and multiplied better, producing about 16 per cent more suckers than did Striped cane. The stalks of the former were smaller, due to the thicker stand.

**381. Japanese sugar cane.** This cane is quite distinct from the other kinds generally cultivated in the United States. The canes are more slender, which makes stripping of leaves more expensive and thus decreases the value of this variety for the manufacture of sirup. Japanese cane is much hardier to cold than other varieties. The stubble, even as far north as latitude 33°, puts out a sufficient number of shoots to insure a stand the next year. A single planting may suffice for a number of years. Only a thin stand is needed at the beginning of the season, since this cane suckers very profusely, fifty or more stems sometimes arising from the same cluster. Its hardiness makes Japanese cane available for sirup even above the central part of the

Gulf states. However, its best use here is as a green soiling food for live stock. Japanese sugar cane is resistant to the mosaic disease.

### HARVESTING AND USES

**382. Stripping, topping, and cutting.** Wherever cane is grown for sugar, the plant is mature enough to be stripped of its leaves when the lower leaves have become brown and partly loosened on the stalk. Another rule as to the best time for cutting cane for sugar making is to wait, if practicable, until the fresh juice is thick enough to show a test of  $8^{\circ}$  on the Baumé spindle. When the usual time for killing frost draws near, stripping and harvesting must be done, even though only a few leaves have loosened. Every additional week during which the cane grows now adds to its percentage of crystallizable sugar (sucrose) and to the purity of the juice and ease of manufacture into sugar.

Stripping and topping are usually done while the plants are standing. However, in the sirup belt the expectation of frost sometimes makes it necessary to cut the cane before stripping. In this case, the canes are piled and protected by their leaves and tops until the stalks can be stripped and ground. After lying thus in piles for a week or more, the leaves somewhat loosen their hold on the stalk, but this is more than overcome by the extra labor required in handling the cut stalks while stripping the leaves.

For stripping the standing plants of cane, a patented stripper enables the laborer in the pine belt to work about twice as rapidly as by using only his hands, but the stalk is not stripped quite so clean of green leaf sheaths as by handwork. A stripper (Fig. 139) consists of a wooden handle, to one end of which are fastened two curved, flexible, dull blades, so arranged that they easily spring apart to admit

the stalk between them. By a thrust against the stalk it slips into the space made by the curve in the blades; then a downward stroke removes the leaves from each side of the plant.

At the time of stripping, the tops also are removed, usually by a cane knife, at a point just above the uppermost joint that is mature or colored. The cut is made higher up for sirup than for sugar making, because the uncrystallizable sugar contained in the upper joints is not harmful in sirup, but is undesirable in the manufacture of sugar. After being



Fig. 139. — An implement for stripping the leaves from sugar cane

stripped and topped, the canes are cut near the ground with cane knives or sharp hoes and are piled at convenient intervals, ready to be hauled to the mill.

In a single test (United States Department of Agriculture, Bureau of Chemistry, *Bulletin* No. 75, p. 29), it was found by chemical analysis that stripping ten days before topping and harvesting had the effect of reducing the percentage of total sugar. It probably also decreased the weight of cane.

By the use of ropes or hay slings laid in the wagon before loading the cane, unloading can be hastened, the large bundles being removed from the wagons by cranes.

In the pine belt the stalks intended for planting are dug rather than cut. This is in order to save the eyes at the base of the stalk and to decrease the danger of decay of the cut cane. Experiments are needed to determine whether the extra labor of digging is justifiable and whether the

cut cane would keep as well as dug cane if the ends were dipped in some disinfectant.

**383. Bedding the cane.** In the pine belt, before the occurrence of the first killing frost in the fall, that part of the crop intended for seed cane is dug, with its adhering leaves and tops, and piled in beds as follows:

A layer of cane is placed on the ground and over this is placed another layer, its roots also resting on the ground, the leaves and tops of this second layer covering most of the first layer. In this way the bed is formed, each layer projecting the lower part of its stalks about ten inches beyond the layer beneath, the tops and leaves of each layer covering the canes below after the manner of shingles. The width of the bed is usually six to ten feet, and the length varies with the amount of seed cane to be kept.

When all the cane has been put in, it is covered with cane leaves, and over all is thrown a layer of earth, completely covering the bed to a depth of three inches in the southern part of the Cotton Belt and slightly deeper farther north.

A rule often followed is to save one sixth of the crop to plant an equal area the next year. The stalks saved for seed usually include all those that are too small to be ground profitably.

**384. Harvesting sugar cane in Louisiana.** Harvesting is done by hand, the laborers at one operation topping, stripping, and cutting the standing cane, using a cane knife. Cane loaders (Fig. 140) are now widely used in Louisiana. These usually consist of a swinging boom mounted on a heavy wagon; a grapple fork, lowered from the end of the boom and operated by a small gasoline engine, lifts the cane from the heaps on the ground to the carts or from the carts into the railroad cars.

Several cane harvesters have been patented. One great difficulty in securing a satisfactory cane harvester is the crooked condition of many of the stalks.

There are elaborate devices for unloading cars at the sugar factories and for carrying the canes thence to the



Fig. 140. — Loading sugar cane

rollers of the mills. Much of the crop is transported by rail from the fields to the sugarhouse.

**385. Time of harvesting.** That part of the crop intended to be planted in the fall is cut early, chiefly before the grinding season begins, and is promptly planted. The canes intended for planting in the spring are cut later, but before being injured by frost, and immediately placed, without

being topped, in windrows in every second water furrow, the tops and leaves of the uppermost plants covering and protecting the stems of those below, lapping like shingles.

Furrows are then thrown on the windrows and the covering of earth is completed by the use of hoes. In spring the surplus soil is removed, and the cane is pulled out by driving suitable implements across the windrows.

This method of keeping planting cane in Louisiana differs from the practice in the pine belt.

**386. Yields of cane.** The average yield for Louisiana is about 20 to 22 tons an acre; 25 tons is a fair yield and many fields produce 30 tons or more. A good average yield of sugar is 150 to 160 pounds a ton, giving an average of more than 3000 pounds to the acre, and, under favorable conditions and in special cases, a yield of 4500 pounds of sugar. An average yield of sugar is accompanied by a yield of molasses amounting to about 100 to 120 gallons an acre. In making sirup alone an average yield in the alluvial lands of Louisiana would be 500 to 600 gallons an acre.

In the sandy uplands of the pine belt the yield is usually smaller, 12 to 15 tons of cane to the acre. However, on the sandier soil the cane is richer in total sugars. In this region it is a poor yield or a poor mill that affords less than 300 gallons of sirup to the acre. Under favorable conditions and with good mills yields above 600 gallons are sometimes made.

In Hawaii, by means of irrigation and the liberal use of fertilizers, yields of more than 100 tons of cane and 24,000 pounds of sugar to the acre have been produced. The average yield of the irrigated plantations in Hawaii is said to be 7 tons of sugar to the acre.

**387. Uses.** Sugar cane is more extensively employed for the production of sugar than for any other purpose. This

is its almost exclusive use in districts where the warm seasons are long, as in Louisiana, Hawaii, and Cuba. In those regions where the climate is warm enough for the growing of sugar cane, but where fall frosts occur too early for the plant to reach the degree of maturity necessary for profitable sugar making, this plant is used for the production of sirup. Since in the United States sugar cane can be grown for sirup over an area considerably larger than that suitable for profitable sugar production, a larger number of farmers are probably engaged in growing this plant for sirup than for sugar. However, the average sirup maker grows but a few acres at most, while in the sugar belt single plantations include hundreds or even thousands of acres of cane.

*Sirup* is the product obtained by boiling the juice from the cane. *Molasses* is a by-product in the manufacture of sugar, and, in its unadulterated form, is much less extensively used on the table than is sirup. *Blackstrap* is the name of a very inferior grade of molasses, chiefly valuable as food for live stock.

The chief difficulty in extending the market for sirup lies in the fact that there is such a wide variation in the quality of sirup made by different farmers. Certain improvements in the methods of making sirup as shown in later paragraphs would result in a more uniform product and in an increased demand.

**388. By-products.** The tops and green leaves of sugar cane make a satisfactory food for live stock. The crushed stalks, called *bagasse*, are seldom utilized in the pine belt, but they are used as fuel in the sugarhouses. From this material also paper has been made successfully. Silage is sometimes made from the tops, leaves, and crushed stalks, after being passed through a silage cutter.

## SIRUP MAKING

**389. The equipment.** The equipment for the making of sirup is not expensive. It consists of a mill for crushing the cane and of a shallow pan, heated by furnace or by steam, for evaporating the juice of the cane down to the density required in sirup.

The small roller mills operated by a single horse often extract only about half of the juice, thus causing an enormous loss. A first-class three-roller mill, properly set, will extract 60 per cent of the weight of the cane or 70 per cent of the total juice. More powerful mills with a larger number of rollers, and usually driven by steam, may express more than 80 per cent of the juice.

The evaporator is usually a rectangular pan placed above a homemade furnace, in which wood furnishes the necessary heat. The bottom of the pan consists of a sheet of copper or galvanized iron, and the sides are usually of wood. In the pan are three divisions, separated by partitions, in which are gates or openings intended to regulate the flow of juice from one compartment to the next one.

When steam is available, it is more convenient to cook the sirup by means of the heat given off by coils of steam pipes laid in the bottom of the evaporating pan. The advantage of steam heat consists in the ability to regulate by a cut-off the amount of heat, and thus to avoid any danger of scorching the sirup.

After being expressed by grinding, the fresh juice is strained and conveyed to the evaporator, where it is heated rather slowly. Heat causes the solid impurities to coagulate or collect in masses of scum. This scum is removed before boiling begins, and repeated skimmings remove all other scum that rises. The boiling is continued

in the next two compartments of the evaporator until the hot sirup has a ropy consistency or, better still, until a Baumé hydrometer, dropped into a slender deep vessel of hot sirup, sinks to the mark on the scale indicating a density of 34°. This instrument, costing only about \$2, is a far safer guide as to when to stop the cooking than is the eye even of an experienced sirup maker. It is essential for all who would make a uniform grade of sirup.

**390. Preventing sirup from turning to sugar.** The first aim in making sirup is to produce an article of an agreeable flavor and nearly clear, or of bright color. The use of immature cane or of cane injudiciously fertilized results in injury to the flavor and appearance of the sirup.

Another important aim in manufacturing sirup is to make a product that will not, at a later date, crystallize, or turn to sugar. The larger the proportion of glucose (or noncrystallizable sugar) in the sirup the less is the danger of the sirup turning to sugar.

Conditions favorable to a large proportion of glucose, and hence to a sirup not easily crystallized, are the following:

(1) Cane not thoroughly ripe in the upper joints, that is, cane topped rather high, since it is these partially ripened internodes that contain the largest proportion of noncrystallizable sugar.

(2) Juice that is slightly acid, as indicated by its changing blue litmus paper to a reddish color. If the perfectly fresh juice is not distinctly acid, it becomes acid after standing for a time, and after being repeatedly strained, by which it is brought into contact with acid-forming germs.

(3) Slow cooking is desirable, since crystallizable sugar may be changed to glucose when heated for a long time in the presence of an acid, as in the acid juice.

(4) Stopping the cooking before the sirup becomes very concentrated checks the tendency to crystallize.

(5) Exclusion of air, by canning or bottling while hot, is an effective means by which sirup is kept from turning to sugar.

**391. Effects of canning.** The sirup that commands the highest price is that which, while still boiling hot, is placed in cans, jugs, bottles, or other air-tight vessels, and promptly sealed, using solder on tins or sealing wax on top of the corks of jugs or bottles.

The reason for placing sirup while hot in air-tight vessels is to prevent the entrance of germs, which would cause the sirup to ferment. Intense heat destroys whatever germs may be present already in the empty vessels. However, it is best first to sterilize these vessels, that is, to kill the germs in them, by the use of steam. It has been found possible to preserve sirup in an unfermented condition in tight barrels which had been sterilized by steam and sealed while the sirup was still very hot. However, it is usually not possible to keep barreled sirup in a completely sterile condition. Hence, barreled sirup should be consumed in winter, while that preserved in sealed cans, jugs, or bottles may be kept safely for use in warm weather.

**392. Use of chemicals in sirup making.** Certain simple chemical substances are freely used in the manufacture of sirup. The clear color and the degree of acidity desirable to prevent sugaring of unsealed sirup are sometimes attained by passing the juice downward in thin layers through a box or barrel in which it is exposed to the ascending fumes of sulfur, burned in a small furnace connected with the bottom of the sulfuring vessel. Too much sulfur injures the flavor.

Recently the United States Department of Agriculture

recommended the addition to the cane juice of a harmless substance to reduce the tendency for sirup to turn to sugar. This substance is known as *invertase*. A circular containing directions for its use may be obtained free from the Department of Agriculture at Washington.

Lime, slaked to a thin paste, is often added to clear the juice by causing the vegetable impurities in the juice to settle. Care is taken not to add enough lime to overcome the acidity of the juice unless means of overcoming the effects of lime are at hand. If the juice should become alkaline, its acidity may be restored by the addition of a little of a preparation called *clariphos* (a pure form of phosphate of lime, which also assists in clarifying the juice).

#### HISTORY AND STATISTICS

**393. Early cultivation.** Sugar cane is a native of Asia and probably of India. It was cultivated in India and China long before the Christian era. Yet not until after the discovery of America did sugar become a very important article of consumption among the inhabitants of Europe and America. The ancient Greeks and Romans seem to have lacked the luxury of sugar.

From Asia sugar cane was carried to the islands of Oceania and to Africa. The Portuguese carried it to the Madeira and Canary Islands, southwest of Europe, whence, soon after the discovery of the New World, it was brought to the West Indies.

From the West Indies sugar cane was introduced into Louisiana and Florida about the middle of the eighteenth century.

The first sugar from sugar cane in what is now the United States was made in Louisiana in 1791, but so small was the quantity that the product was rather an article of curiosity

than of use. In 1795 sugar was first manufactured in Louisiana on an extensive scale. De Bore, the pioneer in sugar making in the United States, made a fortune in growing sugar cane and in manufacturing sugar on his plantation in Louisiana.

**394. Production.** From this small beginning the production of sugar increased so rapidly that at the beginning of the Civil War, within two thirds of a century after the first sugar was manufactured in Louisiana, the annual production of sugar in that state had reached about a quarter of a million tons.

Hawaii and Porto Rico both produce much more sugar than does Louisiana. Cuba produces about three times as much sugar as the total product of all the American states and territories just named. Cuba, British India, and Java are the world's largest producers of sugar cane.

In recent years the world's annual crop of sugar of all kinds has been about 19,000,000 tons, more than two thirds of which was made from sugar cane.

**395. Home consumption.** The United States consumes a larger quantity of sugar in proportion to population than any other country; the Southern States, Hawaii, and Porto Rico together produce only about one quarter of the sugar consumed in the United States. Therefore, there is room for immense expansion in this country in the growing of sugar cane for the manufacture of sugar.

### ENEMIES OF SUGAR CANE

**396. Insects.** The cane borer (*Diatræa saccharalis*) is an important insect enemy of sugar cane in Louisiana and is widely distributed in other cane-growing countries.

The full-grown larva measures about one and a quarter inches in length. It bores into the stalks of cane. Sorghum,

Johnson grass, and corn are also attacked; this insect is also known as the *larger cornstalk borer*.

The best treatment is merely preventive and consists in burning the tops and other litter of the cane in those regions in which this borer is found and in destroying any Johnson grass in and near the cane fields.

The sugar-cane mealy bug is widely distributed in Louisiana cane fields. Alone it is only an unimportant insect, but when Argentine ants are also present the mealy bug becomes a veritable pest, weakening or killing the eyes, or buds, of windrowed or planted cane, thinning the stand, and reducing the yield, often as much as 4 or 5 tons to the acre.

Mealy bugs have been found to increase ten times as fast in the presence of Argentine ants as when alone. This is because these ants — in order to secure as food a maximum supply of the honeydew that is secreted by the mealy bugs — protect the latter from their natural enemies, carry them about, and otherwise tend and protect them. Hence mealy bugs may be controlled by poisoning the Argentine ants with a specially prepared slow-acting sirup mixture containing arsenite of soda. (For formula see Louisiana Experiment Station *Bulletin* No. 185, and other publications on the Argentine ant.)

**397. Diseases.** Red cane, a discoloration of the interior of the stem following cuts or bruises, is harmful if such injured canes are planted.

There are several serious fungous and bacterial diseases of sugar cane occurring in tropical countries. Among the means of escaping many of these is the selection of varieties that show the greatest resistance to these diseases.

*Root disease* is due to a fungus (*Marisnius sacchari*), which may live from season to season in the soil or in the dead and decaying parts of the diseased cane plants. The

disease may be shown above ground by formation of a white moldlike growth on the lower leaves. The plants appear as if suffering from severe drought, due to the loss of many of the small roots killed by this disease. Preventive measures consist in planting canes free from disease, and in practicing rotations that exclude cane from infected fields for a period of two years. It is best that the canes for planting be grown in a special seed field, the "seed cane" for which has either been carefully examined or perhaps disinfected (Louisiana Experiment Station *Bulletin* No. 100). Any methods of improving conditions for the growth of cane, such as drainage and good cultivation, diminish the injury from this disease.

*Mosaic disease* is apparently a comparatively recent introduction into Louisiana and other Southern states. In Porto Rico it has proved very destructive. The diseased plants have foliage of a yellowish-green color, with indistinct narrow stripes. Varieties of cane differ greatly in susceptibility to the mosaic disease; among resistant kinds are the L 511, Purple (Red), or Creole, cane, and Japanese. While this disease is not yet well understood, present recommendations against it are (1) the use of resistant varieties and (2) selection of planting cane from portions of the field showing no indications of disease.

### LABORATORY EXERCISES

(1) Count and record the number of true roots from a node just under the surface of the ground; also the number of dots on a node about a foot above the ground. Do roots develop from most of the dots?

(2) Measure and record in order the length of each internode from the surface of the ground to the uppermost part of the stem.

(3) Cut a cross section through a stalk of sugar cane and make a drawing showing the relative number of bundles near the center and near the rind.

(4) Place the cut end of a cane bearing green leaves in diluted red ink, a few hours later split the next few joints above, and trace the red liquid rising in the water vessels. Make a drawing of one such longitudinal section.

(5) When a cane mill is next seen at work, note the dropping of the liquid from one end of the cane as soon as the roller presses the other end.

(6) If cane that has been kept over winter or subjected to cold weather can be found, cut lengthwise through a live bud and through a dead bud and make a drawing or description of the appearance of each.

(7) Wash away the soil from around a cluster of canes and attempt to determine which is the oldest and which the youngest cane in the cluster.

### ADVANCED TOPICS

A. A library study of effects of fertilizers on yield of sugar cane.

B. Practice and study of sirup making.

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## CHAPTER XXIII

### SWEET POTATÓ (*Batatas batatas*)

The sweet potato belongs to the morning-glory family (Convolvulaceæ), which also includes a number of common weeds and cultivated flowers. This plant has long been cultivated in the tropical and semitropical regions of both the eastern and the western hemispheres. Its origin is somewhat doubtful, but most authorities regard it as a native of America.

**398. Distribution and climate.** The sweet potato is widely grown throughout the warmer regions of America and Asia, as well as to a smaller extent in other countries. This plant requires a warm climate. Its culture on a large scale is confined in the United States to the region lying south of the line drawn through central New Jersey to the southern part of Kansas. A number of the cotton-growing states each produces more than 10,000,000 bushels annually.

The sweet potato grows chiefly during the hottest part of the year. In contrast with the Irish potato, it may be called strictly a summer crop.

The term "potato" when used without modifiers usually means, in the Southern States, sweet potatoes; while elsewhere it signifies the Irish, round, or white, potato.

The season that makes the maximum yield and best quality of sweet potatoes is one in which frequent rains occur during the late spring and the greater part of the summer, but in which there is comparatively dry weather in September and October. Heavy rains near the time of harvest,

especially if they follow a long period of drought, are likely to induce a new growth, which results in harm to the quality and keeping properties of the crop.

**399. Description.** The sweet potato is perennial, but in cultivation it is treated as annual; that is, new propagating material is placed in the soil each year.

The plant has prostrate stems, many of which, in the latter part of the season, take root at the nodes. The leaves

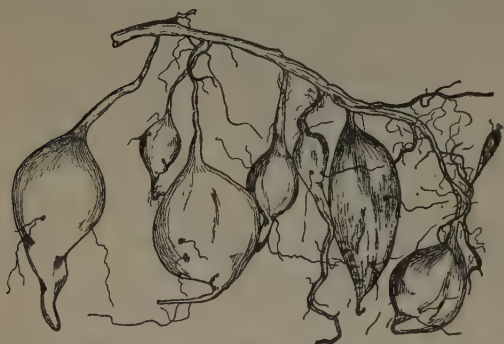


Fig. 141. — Sweet potatoes attached to a section of vine

are extremely variable in shape, and these differences constitute one means of classifying varieties (Figs. 142, 143).

The valuable product is botanically an enlarged root. This is an organ for the storage of food, serving

to hasten the growth of the young shoots, from which the plant is ordinarily propagated. Man converts this stored material to his own use.

Some confusion arises from the fact that the same word "root," when applied to the sweet potato, may denote three parts: (1) the enlarged or 'edible root; (2) the slender fibrous roots which absorb the plant food and moisture from the soil, and (3) the potatoes that are too small for market, but which are used for planting. Therefore, in this chapter, the word "potatoes" will be used to designate the large roots (Fig. 141), as well as to include the whole plant.

The sweet potato seldom produces flowers in the Cotton Belt, and still more rarely, if ever, are perfect seed matured in this region. However, seeds are sometimes matured when the season of growth is prolonged by keeping the plants in a greenhouse. When sweet-potato seeds are planted, they give rise to young plants differing greatly among themselves and most of them unlike their parents. The best of these seedlings may be propagated in the usual way and thus give rise to new varieties.

The blooms of the sweet potato are purplish and in shape and size resemble those of the larger wild morning-glories.

### COMPOSITION AND USES

**400. Uses.** The principal present use of the sweet potato is as a vegetable for human consumption. It is shipped to the Northern markets in enormous quantities. On farms it is also used as feed for live stock, especially for hogs.

TABLE XV. ANALYSES OF ROOTS, VINES, AND DRIED, OR DESICCATED, SWEET POTATOES

	DRY MATTER (Per cent)	ASH (Percent)	PROTEIN (Percent)	FIBER (Percent)	NITROGEN- FREE EXTRACT (Per cent)	FAT ETC. (Percent)
Sweet potatoes, edible roots <sup>1</sup>	31.9	1.0	1.6	0.9	27.9	0.5
Irish potatoes	21.1	1.0	2.1	0.6	17.3	0.1
Dried sweet potatoes <sup>2</sup>	89.5	3.0	4.5	1.9	75.7	1.8
Sweet-potato vines, fresh <sup>3</sup>	17.0	1.5	2.1	3.1	9.5	0.8

<sup>1</sup> Average of 14 varieties grown at South Carolina Experiment Station in 1908 (*Bulletin* No. 146).

<sup>2</sup> *Farmers' Bulletin* No. 129, United States Department of Agriculture.

<sup>3</sup> Calculated from average composition of dry matter found in four varieties; South Carolina Experiment Station *Bulletin* No. 146.

**401. Value as food.** From Table XV, it may be noted that the sweet-potato root is specially rich in nitrogen-free extract, which consists chiefly of starch and sugar. Therefore, in any diet for man or animal, sweet potatoes should be supplemented by foods rich in protein.

The figures show that the sweet-potato root contains about one and one half times as much nutritive matter as an equal weight of Irish potatoes.

Moreover, the protein, or nitrogenous portion, in Irish potatoes is chiefly in the less valuable form, *amides*; while it has been found that amides are not present in the mature sweet potato, all the protein here being in a more valuable form.

Compared with 100 pounds of shelled corn, 300 pounds of sweet potatoes afford slightly more total dry matter and carbonaceous material (starch and sugar) and a little less protein; the theoretical nutritive value of sweet potatoes is approximately one third that of an equal weight of shelled corn.

In order to make advantageous use of the sweet potato as a hog food, it is necessary to use only the unmarketable roots; or else to require the hogs to harvest the crop, thus avoiding the principal item of expense for labor.

**402. Starch and alcohol.** It seems probable that the sweet potato will become an important crop for the manufacture of starch, an excellent quality of which has been made from this crop. Sweet potatoes usually contain 15 to 20 per cent of starch. This is a higher percentage than in the Irish potato, which is now a standard source of starch. The sweet potato is also a possible source for the manufacture of denatured alcohol for use as fuel and in the arts. A bushel of sweet potatoes is expected to make nearly one gallon of industrial alcohol. Moreover, in the manufacture

of starch, after this substance is removed, alcohol could be made as a by-product from some of the waste material.

**403. Draft on soil fertility.** The sweet potato removes much potash and also rather large amounts of other plant food, as shown by analyses:

TABLE XVI. AMOUNTS OF PLANT FOOD REMOVED FROM SOIL BY SWEET POTATOES

	NITRO- GEN (Per cent)	PHOS- PHORIC ACID (Per cent)	POTASH (Per cent)
Sweet potatoes, edible roots (N. J.) . . . . .	0.23	0.10	0.50
Sweet potatoes, edible roots (S. C.) . . . . .	.25	.07	.45
Sweet potatoes, edible roots (Cal.) . . . . .	.30	.17	.63
Sweet potatoes, edible roots, average of above . . . . .	<b>.26</b>	<b>.11</b>	<b>.53</b>
Sweet potato, fresh vines (Md., 83% water) <sup>1</sup> . . . . .	.42	.07	.73
Sweet potato, fresh vines (S. C., 83% water) <sup>2</sup> . . . . .	.34	.05	.48
Fresh vines, average of above . . . . .	<b>.38</b>	<b>.06</b>	<b>.60</b>

The roots of sweet potatoes remove about twice as much potash as nitrogen and about five times as much potash as phosphoric acid. The fresh vines have been found to weigh considerably more than half as much as the edible roots and to be richer in nitrogen.

According to the average figures in Table XVI a crop of 200 bushels would remove in the edible roots alone 31 pounds of nitrogen, 13 pounds of phosphoric acid, 64 pounds of potash.

#### VARIETIES

**404. Terms used.** Great confusion exists in the names and qualities of varieties of sweet potatoes. This is partly due to the fact that many different names are locally applied

<sup>1</sup> *Farmers' Bulletin* No. 26, United States Department of Agriculture.

<sup>2</sup> South Carolina Experiment Station *Bulletin* No. 146, p. 18.

to the same variety; partly to the ease with which the tubers of different varieties become mechanically mixed; and partly, perhaps, to natural variations occurring in the same variety under different conditions of climate and cultivation.

The word "yam" is used as a part of a name of some varieties. Often it is applied to those varieties having a soft texture and sirupy flavor; it is also frequently used for varieties having deeply cut leaves; and it has even been applied to those potatoes which have prominent veins on the roots. Its meaning is so indefinite and variable that the term might better be dropped, especially since the word "yam" is properly applied to an entirely different genus of plants, *Dioscorea*, of the yam family, largely grown in the West Indies and elsewhere as food for the natives.

**405. Market demands.** As a rule the Southern consumer, whether on the farm or in a city, prefers a soft sirupy potato, which qualities are still further developed by baking, the common Southern method of cooking this vegetable. On the other hand, the Northern markets demand a dry, mealy, or starchy potato, probably partly because the more common method of cooking consists in boiling. It is stated that in the latter part of winter there is more demand than earlier in Northern markets for the sirupy type of potato.

Among varieties popular in the Northern markets are Nansemond and Big Stem Jersey. The Dooley is a popular variety among the Southern consumers. Porto Rico and Nancy Hall are extensively grown for market and for home consumption. Triumph is sometimes grown for the Northern market.

**406. Desirable qualities.** The qualities most desirable in a variety of potatoes are (1) texture and flavor of the kind demanded by the market for which the crop is grown; (2) productiveness, and (3) keeping qualities.

To supply the market for a few weeks in the latter part of summer, there is also need for early varieties, which, however, are usually inferior in quality.

When potatoes are grown chiefly as a stock feed, yield is the main consideration. As a rule, the most productive varieties have a hard texture and high percentage of dry matter and are not favorites for the table. Among the most productive kinds is Southern Queen.

**407. Classification of varieties.** No system of classification is thoroughly satisfactory. For the sake of convenience, varieties may be divided into four groups as follows:

Group I. Bunch, or vineless, varieties, having short vines, with leaf stems closely crowded together (Fig. 142); leaves usually deeply cut (Fig. 143).

Group II. Leaves deeply cut; vines long.

Group III. Leaves shouldered or very slightly lobed (Fig. 143); vines long.

Group IV. Leaves with margins entire or nearly unbroken by lobes or shoulders (Fig. 143); vines long.



Fig. 142. — A branch of a vineless sweet-potato plant

Note the crowded position of the leaf stems.

Each of these groups, except possibly the vineless varieties, may be subdivided into three classes, according to the texture and flavor, which may be either sirupy, mealy, or intermediate. Each of these subdivisions may be subdivided further into three groups, according to whether the uncooked flesh is yellow, white, or mottled white and yellow. Each of these last subdivisions can be separated still further into four divisions, according as the skin of the potato is white, yellowish, light red, or purple (dark reddish). If all of these classes should have repre-

sentatives, there would be 144 different classes. However, the vineless has only a few subdivisions at the present time.

Examples of the bunch varieties are found in the several strains of vineless, which appear to differ somewhat in quality and yield.

Among the varieties of the cut-leaf type with long vines are the following: Sugar, or Yellow Yam, and its synonyms, all of which have a sirupy quality but are relatively unproductive; the Spanish has cut leaves and a mealy texture.



Fig. 143. — Three shapes of sweet-potato leaves

Among varieties having shouldered leaves is the Yellow Nansemond which has a mealy texture.

Among the varieties with leaves almost entire are Pumpkin Yam, or Dooley, which has a sirupy flavor; and among those with a starchy texture are Southern Queen and Hayman.

#### SOILS, FERTILIZERS, AND ROTATION

**408. Soils.** For the best results in quantity and quality, the soil for sweet potatoes should have the following properties: (1) It should be mellow, so as not to bake and so that the roots may penetrate it easily and fully develop

without undue pressure; (2) it should be warm, so as to promote a long period of active growth; and (3) it should be well drained, so that growth may be vigorous and the quality of the crop good. These conditions are best filled by a sandy-loam or sandy soil. On a given farm, the soil which contains the largest proportion of sand is usually devoted to the cultivation of sweet potatoes.

However, this crop is not confined to sandy land. On some clay soils, especially if rich in lime, large yields are made; but here the crop is later, of somewhat poorer quality, and liable to be of inferior appearance by reason of adhering particles of soil. Moreover, harvesting is more laborious in clay than in sandy soils.

**409. Humus.** If sweet potatoes must be grown where there is much clay, there should be also an abundant supply of humus, so as to make the soil mellow and free from a tendency to bake. In fact, whatever may be the nature of the soil, humus is an important constituent for the best results with sweet potatoes.

**410. Fertilizers.** Since both the roots and the vines of sweet potatoes contain much more potash than either nitrogen or phosphoric acid, therefore, the fertilizer should be rich in potash. Moreover, sandy soil, the type usually selected for sweet potatoes, is generally more deficient in potash than is stiffer land.

This crop makes heavy demands for nitrogen also. The cheapest means of supplying it consist in growing a preceding crop of crimson clover, cowpeas, or other legumes.

Acid phosphate has also been found by experience to be needed in fertilizer formulas for sweet potatoes.

Farmers in the cotton states are sometimes afraid to use stable manure or other nitrogenous fertilizers, lest the crop "run chiefly to vines." When the fertilizer is properly

balanced, that is, made up of the proper proportion of nitrogen, phosphoric acid, and potash, there is little, if any, danger that the growth of vines will be excessive. Only by the development of a large growth of vines can a maximum crop of roots be secured; for the starch and other valuable material, of which the roots largely consist, can be manufactured only by an abundance of leaves and other green portions of the plant.

In the parts of New Jersey where this crop is extensively grown for market and large yields are secured, it is not unusual for a farmer to apply 10 tons of manure to the acre for sweet potatoes in addition to 500 to 1000 pounds of commercial fertilizer.

**411. Place in the rotation.** Since a field of sweet potatoes needs to be kept free from grass and weeds at the least expense, it is generally advisable for this crop to follow one which leaves the land clean; that is, relatively free from seeds of weeds and grass. One of the best of such crops to precede sweet potatoes is cotton.

It is also advantageous that the preceding crop supply a large amount of humus. Cowpeas or velvet beans answer this purpose well, if so grown as to keep down the growth of weeds. One of the best means of supplying both humus and nitrogen consists in growing a preceding catch crop of crimson clover to be plowed under in April as a preparation for sweet potatoes.

**412. Effect on land.** The large quantities of manures and fertilizers sometimes employed for sweet potatoes tend to make this field produce good crops the next year, provided the vines are left on the land and somewhat evenly distributed. However, the sweet potato itself is an exhaustive crop on account (1) of the large amounts of potash and nitrogen removed and (2) of the leaching of the soil by

winter rain, which is likely to be especially great on a field plowed in the fall and left bare of vegetation during winter. To prevent this leaching, it is advisable, where practicable, to sow a small grain or some winter cover crop after harvesting sweet potatoes.

### CULTURAL METHODS

**413. How propagated.** The sweet potato is propagated without the use of seed. The most common method consists in placing the roots in beds, where, under the influence of proper amounts of heat and moisture, the buds or eyes develop into shoots. These shoots, variously called "slips," "draws," or "sets," are the means by which the greater part of the acreage is grown. A second method consists in cutting sections of vines from plants produced by slips and in setting these vines in the field rather late in the season. A third method, seldom employed, consists in cutting the potato into small pieces and planting these sections just as one would plant Irish potatoes.

**414. Bedding sweet potatoes.** About six weeks before setting the slips in the field, the enlarged roots are placed in specially constructed beds, for the purpose of stimulating, by means of heat and moisture, the development of buds and shoots.

The source of heat for small beds may be a layer of fermenting stable manure. However, flue heat, long employed in the trucking regions of New Jersey, Maryland, Delaware, and Virginia, is now generally used by the largest commercial growers throughout the South.

**415. Manure bed.** A bed to be heated by manure is usually made as follows: In a well-drained sheltered spot, the soil is excavated to a depth of six or more inches, and a simple frame made with side and end boards. A layer

of moist stable manure, with a depth of four to eight inches, is packed in; and over this is placed a layer of about four inches of sand or fine, loamy soil to keep the potatoes from coming in immediate contact with the manure, which would rot or dry them. It is best to let the excess of heat pass off, by waiting a few days before placing the potatoes in the bed. Then, or as soon as the bed is ready, they are pressed into the soft layer of earth, being placed as near together as possible without touching. They are then covered with a layer of sand or loamy soil, which should cover the most exposed roots to a depth of at least two inches. For an early crop a movable covering of pine leaves, or of cloth, or even a glass sash is sometimes employed. If leaves are used, they must be removed as soon as sprouts appear, to avoid long tender slips. If glass is used, care must be given to ventilation. A trench around the outside provides for drainage.

When necessary, this bed is watered. Excess of water should be avoided, especially before the sprouts appear.

**416. Fire-heated hotbeds.** These consist of a board floor under which is a shallow trench or series of trenches or lines of tile. These trenches serve to convey the heat and smoke under the entire length of the bed, that is, from the furnace to the chimney. The furnace, cheaply constructed of brick, is at the lower end of the long bed, so that the heat, on its way to the wooden chimney at the opposite end, may travel up a gradual incline while warming the layer of soil above. The floor is covered with about five inches of soil, in which the potatoes are bedded and covered with additional soil, just as in the common type of bed.

The slope of the floor should be about 1 foot in 20. The furnace, which is usually 6 feet long by about 2 feet 6 inches in the other dimensions, is made of brick and sunk to such

a depth in the ground at the lower end of the bed as to give the necessary slope to the flues. The flues for a bed 12 feet wide often consist of three lines of six-inch tiles and should extend about 30 feet from the furnace, at which point they empty their heat and smoke into the large air space under the floor. Over the furnace is a layer of soil about 1 foot deep; over the flue the depth of this layer gradually decreases. The chimney should be provided with a damper to regulate the draft. The effort is to keep the temperature of the soil in which the potatoes are bedded at about 80° to 85° F.

**417. Kind and quantity of potatoes to bed.** A bushel of small potatoes affords a larger number of slips than does a bushel of roots of larger size. This is because the greater number of small potatoes possesses a greater total surface area from which buds grow out. Farmers give preference for bedding to roots of small to medium size. It has not been proved that small but well-shaped potatoes cause any decrease in the size of the roots of the next crop. However, in the case of a mechanical mixture of several varieties or strains, the exclusive use, year after year, of the ill-shaped stringy roots would result in time in a crop consisting chiefly of the inferior strain or variety having the greatest proportion of undesirable potatoes. So far as present information goes, the small potatoes make just as good "seed stock" as large roots from the same hill.

A bushel of medium-sized potatoes covers about 15 to 20 square feet of surface when bedded; a bushel of small roots requires 25 square feet or more of bed. At the first drawing, a bushel of bedded potatoes may be expected to afford 800 to 1500 slips, besides which it usually affords a smaller number at the second, and again at the third drawing. For each acre to be set out with the slips from three drawings, it is well to allow at least 2 bushels of very small potatoes and

at least double this amount with roots of medium size. To plant the entire area early, that is, chiefly from the first drawing, these amounts will need to be about doubled. By using vine cuttings, clipped from the plants set out early, the acreage can be increased without additional expenditure for "seed potatoes."

**418. Drawing or removing the slips.** When the shoots show a length of about four inches above ground, or a total length of six or seven inches, and when roots have begun to develop on the lower parts of these slips, they should be drawn and transplanted to the field. The bed should first be watered. The slips should be carefully pulled so as not to move the "seed potatoes."



Fig. 144. — Implements for setting sweet-potato slips and vine cuttings

By keeping the bed watered, it should be ready to afford a second drawing about ten to fourteen days after the first, and then after a still longer interval, a third drawing can often be made.

**419. Transplanting.** The rows are first flattened with a harrow or board, so as to destroy the crust and young vegetation, and to insure a soft bed of soil. Then careful growers mark the rows with suitable devices so as to make the plants stand at uniform distances apart. One person drops the slip near its position, and another inserts it in place, carefully pressing the soil around the slip. In setting out potatoes, the farmer uses either a garden dibble or small trowel, or a short sharpened stick; on soft soil the slip is pressed into place by the use of special devices, about as long as a walking stick, which usually consist of either (1) a single lath, having a

base hollowed out and covered with leather or (2) wooden tongs made of two laths (Fig. 144).

On many farms, it is customary to wait for a rain and to transplant the slips or vine cuttings only after a rain. If the land has been well prepared and repeatedly harrowed, it is not necessary to wait on the weather. Some growers prefer to set slips without a rain. In the latter case it is usual to water the plants. The water serves to settle the soil more closely around the stem than would be possible if reliance were placed entirely on the moisture in the soil. After watering sweet potatoes or any other plant, one must be careful to cover the watered spots with a thin layer of dry soil, to prevent evaporation and baking.

**420. Transplanting machines.** When a large acreage is cultivated in sweet potatoes, it is profitable to employ a transplanting machine (Fig. 145). It sets and waters the plants as fast as the team pulls the machine along the rows. Two men on seats at the rear drop the plants at the required intervals.



Fig. 145. — A transplanting machine

**421. Time of transplanting.** Bedding may be done about three weeks before the time when the last light frost is expected. The soil must be well warmed before transplanted slips will thrive in the field. In the central part of the Cotton Belt, transplanting about April 1 may be regarded as early. To determine the last date at which setting in

the field may be done with the expectation of a fair yield, a period of at least three and a half months should be allowed before the usual date of the first fall frost. In this region, it scarcely pays to set slips or vines after July 15; and in general the yield from the late plantings are much smaller than from those made in mid-season.

**422. Propagation by the use of vine cuttings.** When the bedded potatoes do not furnish enough slips for the desired area, they may be supplemented by setting out in June or early July sections of about 18 inches of vine cut from the early plants. Vine cuttings are usually set out just after a rain by a stick or lath with concave base, pressed down on the center of the vine.

Roots produced by vine cuttings are preferred for bedding. This is because such potatoes usually escape black rot, a disease which, if present in the bed, is conveyed to the slips by the diseased potatoes. The preference for potatoes from vine cuttings may also be due to their greater soundness, sometimes attributable to the late date of planting.

**423. Distance between plants.** In the cotton states, the rows are usually about  $3\frac{1}{2}$  feet apart. Truckers sometimes plant in narrower rows. In several experiments a distance of 18 inches between plants afforded larger yields than were obtained either by closer or wider spacing.

**424. Preparation of land.** It too frequently happens that the land is merely thrown into beds without any previous plowing. For this crop, which makes a large yield to the acre and requires a soft mellow soil for the easy transplanting of the slips and for the full development of the crop, it is profitable to give thorough preparation. This should consist of broadcast plowing, repeated harrowing, and the formation of beds, which are usually thrown up over a furrow in

which fertilizer has been applied. Before bedding and after the fertilizer is drilled in, the latter should be incorporated thoroughly with the soil by running some cultivating implement in the open furrow. It is usually better for the beds to be formed several weeks before the date of transplanting, so as to permit the soil to be settled by rain. The beds should be kept covered with a loose layer of soil and free from crust and vegetation by the repeated use of a light harrow.

To produce the largest yield, the depth of plowing should be considerable, and deep plowing should probably be the rule when the crop is to be used as stock feed. However, the market prefers a rather short potato, and this shape is favored by rather shallow plowing; that is, to a depth of not more than 5 inches.

While level tillage can be practiced for sweet potatoes set out late on sandy well-drained soil, it is probably advisable for the planting, as a rule, to be done on beds; however, these should be pulled down by the use of the harrow until elevated only 3 or 4 inches above the water furrows. Planting on low ridges affords a warmer, more perfectly drained soil. The extremely high ridges sometimes seen add greatly to the cost of cultivation, and unless the season is very wet, high ridges do not materially increase the yield.

**425. Tillage.** Tillage should be frequent and shallow. The most satisfactory implements are those forms of one-horse cultivators equipped with small points, so as to be run as near as possible to the plants without covering them with soil. A scrape or any other implement doing shallow work is also suitable. Just before each cultivation, if the vines have begun to run, they should be turned into alternate middles by the use of a stick, so as to get them out of the way of the implement. At the next cultivation the position

of the vines is reversed. Tillage usually ceases when the vines meet across the row, though it is still desirable to pull or remove with a hoe large weeds and bunches of grass.

Some cultivators are equipped with a vine-lifting attachment, which makes it unnecessary to move the vines into alternate middles by hand.

**426. Pruning the vines.** Experiments have shown that pruning the vines in order to obtain vine cuttings for propagation reduces the yield. The few experiments so far made do not agree in showing any advantage from the custom of lifting or moving the vines late in the season to prevent their rooting at the joints or nodes.

#### HARVESTING AND STORING SWEET POTATOES

**427. When to dig potatoes.** The root of the sweet potato has not reached maturity and condition for storage until, when a cut is made, the wound heals over with a whitish appearance. If the broken place becomes discolored, the potato is immature.

Since the price is much higher in August and early in September than during October and November, a part of the crop may be dug very early, even at a sacrifice of yield and maturity. The bulk of the crop is not dug until near the time of the first fall frost. Some investigators conclude that sweet potatoes keep better if dug well in advance of frost.

**428. Yields.** The average yield for the entire acreage cultivated in sweet potatoes in the United States is usually reported as about 100 bushels an acre. Good farmers expect to make fully 200 bushels, and yields above 500 bushels to the acre have been reported repeatedly.

**429. Methods of harvesting.** The long vines must first be disposed of. They are usually pulled by running a plow

on each side of the row. This work is done much more satisfactorily if the line of plants is barred off with a turnplow, to the beam of which is attached a rolling coulter, which cuts the vines close to the row. The potatoes are then upturned by the use of a large turnplow (Fig. 146).

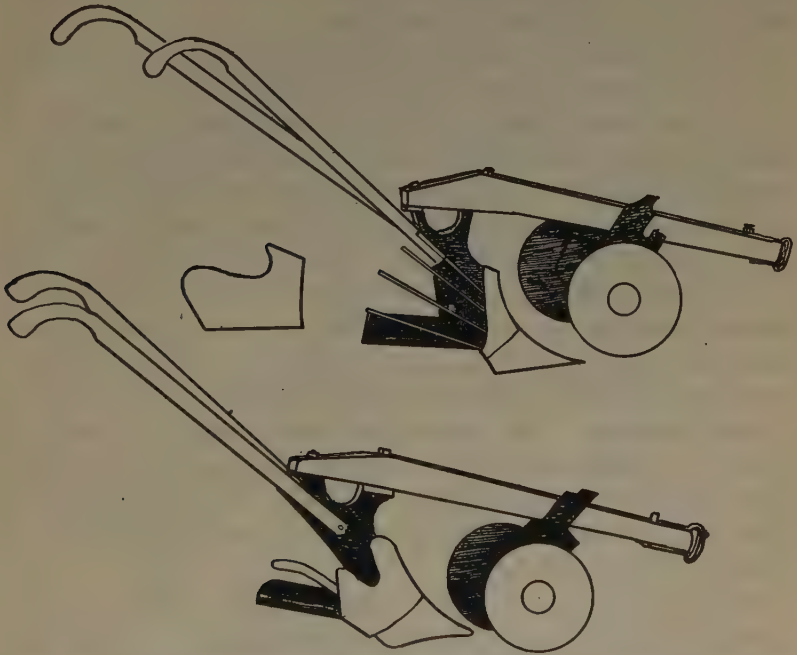


Fig. 146. — Special plows for digging sweet potatoes

If the work of harvesting is performed by careful laborers, sorting may be done in the field, the injured and unmarketable roots being gathered in different baskets from those containing the marketable potatoes. With less careful labor, it is better to gather all potatoes together, sorting them at the place of storage or of packing. Extreme care should be

taken to avoid bruising the potatoes since germs of decay enter through bruises and cuts.

**430. Conditions necessary in storing potatoes.** In order that sweet potatoes may keep in perfect condition throughout the winter, so as to prolong the time of use or to be sold at the higher prices prevailing after Christmas, they must fulfill the following conditions:

(1) The potatoes when stored must be sound, all bruised, cut, or diseased potatoes being excluded from storage.

(2) The roots must be subjected to a certain degree of drying or evaporation, which may be induced either by ventilation alone while the potatoes are kept in the shade, or by exposure to artificial heat, combined with ventilation.

(3) Rats and mice must be excluded carefully.

(4) The potatoes must not be allowed to become so much colder than the air coming in contact with them as to cause the latter to condense or deposit its contained moisture upon the cold surface of the potatoes.

**431. Banking.** The method in common use in the cotton states by those who store potatoes for home use, or in small quantities for market, consists in keeping them through the winter in conical banks or mounds, each containing 10 to 25 bushels.

To make a potato bank, cut a small circular trench around a well-drained, somewhat sheltered spot. With the excavated earth, slightly build up the ground on which the heap is to stand. Place a layer of straw over this, and on it build up a cone-shaped heap of potatoes around a central ventilator, made of several poles or boards. Cover the potatoes with pine needles or with clean dry straw. Over the straw or leaves, place a layer of cornstalks to support the weight of the outer covering of soil. A few weeks later, after the potatoes have gone through a sweat, and

before cold weather, place a layer of soil over the corn stalks; and in cold weather, stop the ventilator with a capping of hay. The whole is best inclosed under a cheap shelter of boards, though sometimes the bank is left with no covering except a few boards placed over the ventilator.

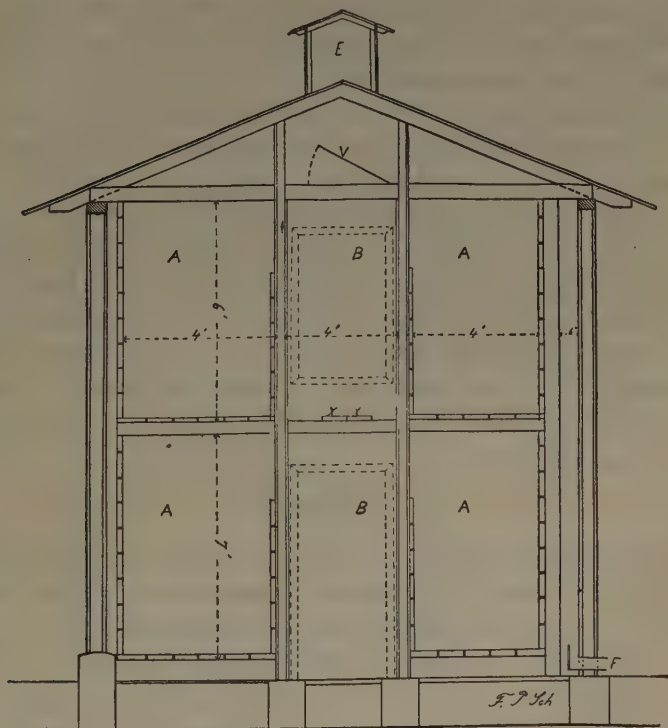


Fig. 147. — End view of house for storing sweet potatoes

*A, A, A, A*, bins with slotted floor and walls; *B, B*, passageways, above and below, with doors at the ends; *V*, ventilating door; *x, x*, loose boards forming floor of upper passageway; *E*, ventilator; *F*, air flue.

· 432. Curing houses for sweet potatoes. For marketing in winter sweet potatoes are stored in houses of special construction (Fig. 147). In these the loss from decay is

very much less than in storage banks. Stove heat is employed, especially during the first ten days or more of storage and in the coldest weather in winter.

Storage houses vary in capacity from a few hundred bushels to many thousand. The essential features of construction are the following: (1) tight double walls; (2) ample ventilators; and (3) bins slatted on all sides and bottoms, so that the air has free access.

An ordinary stove with stovepipe and flue is placed in this house. For the first ten to fourteen days fire is kept burning so as to maintain a temperature of nearly 90°, thus driving off surplus moisture and preventing sweating. Again in cold or damp weather in winter, fires are maintained in order to keep the air inside warmer and drier than that outside. One main purpose in managing the fire and the ventilators is to prevent condensation of the moisture of the air upon the cool surface of the potatoes. The preferred winter temperature within the storage house is around 50° F.

## ENEMIES

**433. Insects.** Most destructive of the insects attacking the sweet potato is the sweet-potato weevil (*Cylas formicarius*). It tunnels through and ruins the maturing potatoes. No treatment is known except to avoid infested potatoes for both storing and bedding. Strict quarantines are enforced to prevent the spread of this insect. When it has been discovered soon after its introduction, it has been completely eradicated from some localities.

**434. Fungous diseases.** The enlarged root of the sweet potato is subject to various forms of decay, each one due to a different germ, or disease-producing organism. The most serious of these is the black rot (*Ceratocystis fimbriata*).

The presence of this fungus within the potato root causes black spots on the surface. These spots are slightly depressed, and the dark color extends deep into the enlarged root, which completely decays in the field or during storage. If diseased potatoes are bedded, the slips are also diseased. The remedies consist in (1) bedding no tubers thus diseased; (2) destroying any slips on the white stems of which are found any dark spots; (3) rotation of crops; and (4) soaking the seed potatoes for 10 minutes in a solution of one part of corrosive sublimate to 1000 parts of water.

### LABORATORY EXERCISES

(1) If practicable, prepare and plant a propagating bed of sweet potatoes. If this can not be done, place at least a few sweet potatoes in damp soil in a box kept in a warm place. As soon as buds and shoots develop make drawings of (*a*) a sweet potato, with sprouting buds, and of (*b*) a detached slip, or shoot, long enough to be transplanted, showing especially the location of the roots.

(2) Make a drawing showing the position and direction of the enlarged roots (potatoes) as they grow in the soil.

(3) Students should participate in any of the operations connected with the growing of this crop which may be in progress when this chapter is studied.

(4) If this subject is studied in the fall, a storage bank of sweet potatoes should be made by the students, or else inspection made of a bank or potato house on some farm in the neighborhood.

### ADVANCED TOPICS

A. A library study of the results of fertilizer experiments with sweet potatoes.

B. A field and library study of sweet-potato storage houses.

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## CHAPTER XXIV

### TOBACCO (*Nicotiana tabacum*)

Tobacco belongs to the nightshade family (Solanaceæ). This family also includes the Irish potato, tomato, and the Jimson weed.

Tobacco is used chiefly for human consumption, the habit of chewing and smoking being general throughout a large part of the world. Snuff, insecticides, and some other articles are also manufactured from tobacco. The stems and other cheap by-products make valuable fertilizers.

**435. Description.** Tobacco is annual and makes its growth during the warm season. The plant has a stout stem, usually 4 to 7 feet high, from which grow large thin leaves, which constitute the valuable part of the plant. The root system is rather shallow; the leaves vary in size and shape in different types and varieties of tobacco. They are arranged in eight vertical ranks, so that the ninth leaf is immediately above the first or lowest leaf, a fact which enables the farmer to top the plant to a definite number of leaves without stopping to count all of them.

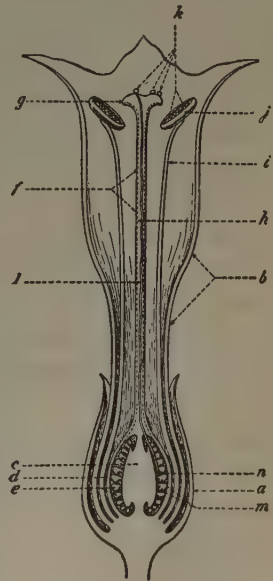


Fig. 148. — Drawing of a tobacco flower

*a*, calyx; *b*, corolla; *c*, interior of seed capsule; *f*, pistil; *i*, stalk of stamen; *j*, stamen; *k*, pollen grains; *l*, pollen tube.

**436. Distribution of tobacco.** The first settlers in America found the Indians cultivating tobacco, and this soon became the leading cash crop of the Virginia and Maryland colonists. It even became the medium of exchange, taking the place of money. Tobacco is now extensively grown in certain restricted sections from Connecticut to Texas. Among the Southern States Kentucky is the largest producer, followed by North Carolina and Virginia. In recent decades, the production of a high-grade cigar tobacco has become a leading industry in the northern part of Florida and in other localities in the Gulf states.

**437. Composition.** All kinds of tobacco contain varying quantities of the narcotic alkaloid, nicotine, which is a recognized poison. The heavier and stronger the leaf, the larger, as a rule, is the proportion of nicotine.

All parts of the tobacco plant are rich in potash and nitrogen and also contain considerable amounts of phosphoric acid. Tobacco is an exhausting crop.

**438. Soils and their relation to types of tobacco.** None of the ordinary crops of the farm is so much influenced in quality by the soil on which grown as is tobacco. For this reason tobacco culture is largely confined to restricted areas and to particular soils. An exact description of the soils suited to each type is not easily made. In general, cigar tobacco and other kinds in which a thin leaf is desirable succeed best on rather light or sandy soils. On the other hand, heavy or dark tobacco is best suited to stiffer land. Burley tobacco is grown almost exclusively on limestone soils, chiefly in Kentucky and adjacent states.

For most grades of tobacco newly cleared land is preferred, since an abundance of humus is desirable. For this reason growers of this crop have cleared most of the forests from the best soils of the tobacco districts.

The dark export tobacco of Virginia is largely grown on the reddish soils described as Cecil sandy loam and Cecil clay.

Cuban cigar tobacco thrives best on gray sandy soils and on the Orangeburg series, consisting of a fine sandy loam or clay loam, with stiffer reddish clay-loam subsoil.

For Sumatra tobacco in Florida, gray, sandy, hammock land, new and rich, is preferred. There are many other special kinds of soil suited to particular types of tobacco.

**439. Fertilizers.** Because tobacco removes from the soil a large amount of potash and nitrogen, and for many other reasons (including the desirability that the plant should make a rapid and continuous growth), tobacco is liberally fertilized. The chief reliance is on commercial fertilizers.

The form in which potash is applied is especially important. Muriate of potash and kainit should both be avoided, because of the large amount of chlorine found in both, which element is unfavorable to the burning qualities and other properties of tobacco. Instead, potash is best applied in the form of carbonate or sulfate of potash.

**440. Nitrogen supply.** Nitrogen may be applied in several forms: Organic nitrogen, supplied by cottonseed meal, dried blood, and the like, is a preferred form. Nitrate of soda is also used in moderate amounts. A mixture of organic nitrogen and of nitrate of soda is apparently preferable to either alone. Barnyard manure usually makes the leaf coarser than it would otherwise be; yet cow manure has been advised for shade-grown Sumatra tobacco in Florida. A complete fertilizer is usually necessary. Customary amounts are 600 to 1200 pounds, which is sometimes increased for shade-grown tobacco to fully 3000 pounds an acre.

**441. Types and varieties of tobacco.** "The principal types of tobacco are the following: (1) Cigar wrapper and binder; (2) cigar filler; (3) chewing, or plug; (4) smoking; (5) export tobaccos." Types refer chiefly to the principal use made of each kind and to the market for each.

Cigar wrapper and binder tobacco is produced from several widely different varieties, the kind commanding the highest price being the Sumatra, grown under cloth or slat shade, chiefly along the Gulf coast.



Fig. 149. — A tobacco plant

The dark heavy tobaccos of southern Virginia and of Tennessee — for example, the varieties Blue Pryor and Orinoco—belong chiefly to the chewing, or plug, and to the export types. The greater part of the bright tobacco of North Carolina and of the light-colored tobaccos of Virginia and Maryland are employed for smoking.

The White Burley, grown in Kentucky, is chiefly used for chewing tobacco, but also for smoking.

**442. Saving seed and tobacco breeding.** The large conspicuous flowers (Figs. 148, 149) of tobacco are borne in clusters. The flowers are either self-pollinated or cross-

pollinated. Experiments have demonstrated that by inclosing the flower buds under paper bags so as to prevent cross-pollination, the plants from seed thus produced are more uniform, productive, and vigorous than when cross-pollination is permitted. The largest tobacco seeds produce much better plants than the smallest. A special device, or blower, has been invented for use in removing the smaller seed from those to be planted (Fig. 150).

### CULTURAL METHODS

**443. Seed bed.** The seed of tobacco are so minute, requiring about 5,000,000 to make one pound, that it is necessary to germinate the seed and start the young plants in a specially prepared seed bed, from which they are later transplanted to the field. The preferred location for a seed bed is on recently cleared land.

As a rule, brush and wood are burned on the chosen spot until the soil has been well heated to a depth of about three inches. The chief object of this is to destroy weed seeds. Then the soil is fertilized and thoroughly pulverized by raking. The bed is inclosed on all sides by a board frame.

After raking in the fertilizer, preferably a week or more before planting the bed, the seed are sown and the frame covered with light cotton cloth. The purpose of the canvas covering is to retain the moisture and heat and hence to hasten germination and growth. The cloth also keeps out some injurious insects. This covering should be removed about

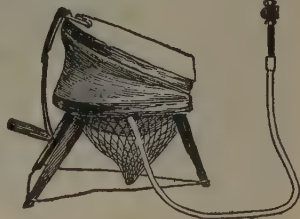


Fig. 150. — A tobacco-seed blower

a week before the plants are to be set in the field, so that they may become toughened.

**444. Sowing the seed.** The seed are sowed in January or February or, in the cooler parts of the South, in March. The seed are first mixed with wood ashes or corn meal, so that they may be distributed more evenly. Further to insure uniformity of distribution, half of the seed are usually sown broadcast in one direction over the entire bed, and the remainder are then sown crosswise to the direction of the first sowing. The seed are pressed into the soil with a light roller or by the use of the feet, sometimes after the surface has been very lightly raked, brushed, or whipped. The amount used is from one to two tablespoonfuls for each one hundred square yards of tobacco bed. Covering is shallow.

**445. Preparation and setting plants.** For tobacco the land should be prepared thoroughly a number of weeks or even months in advance of transplanting. Fertilizers are applied and mixed in the rows, which are usually 3 or 3½ feet apart. After the plants are of sufficient size, all danger of frost past, and the soil thoroughly warmed, the young plants are set at intervals of 14 to 36 inches in the row.

Plants are usually ready to be set in the field nine to ten weeks after the sowing of the seed, or at a shorter interval when the seed bed is planted late. Cultivation should be frequent and thorough.

**446. Topping.** This practice consists in removing the main, or central, flower bud together with such a number of the upper leaves as will save only the number of leaves found best to mature for each variety of tobacco and for each class of soil.

The object of topping is (1) to increase the size of the remaining leaves by concentrating in them more of the

elaborated plant food; (2) to make the leaves thicker and of stronger quality; and (3) to make the crop mature as uniformly as possible. The general rule is that the fewer the leaves left, the larger, thicker, and stronger in quality will they be. On the other hand, high topping results in leaves



Fig. 151. — A fine field of tobacco

© H. P. Cook

of reduced size, but having the thinness that is prized in cigar wrappers.

The number of leaves left varies greatly among the different types. In heavy tobacco it is usually 8 to 10, in Burley at least 14, in Cuban at least 16; in shade-grown Sumatra 25 or more leaves may be permitted to mature. With Sumatra tobacco, grown under shade, topping is sometimes

omitted if the land is very rich, the aim in this case being to make the leaves thinner than if the plants were topped.

**447. Suckering.** Soon after the plants are topped, branches, or suckers, grow from the axils of the leaves. These should be pinched or broken off before they have received much of the plant's supply of nourishment. This process of suckering, or removing of suckers, should be done at such frequent intervals as to prevent their reaching a length of much more than two inches. The object in suckering is to prevent the diversion of plant food and growth into these branches and to concentrate growth in the best or middle leaves.

**448. Growing tobacco under shade.** It has been found by experience that tobacco grown under artificial shade affords the highest quality of cigar wrappers and the largest proportion of leaves fit for this use. This is the common method of growing Sumatra and Cuban tobacco for cigar wrappers.

A "shade" consists of a field inclosed by a solid wooden wall about 9 feet high, the entire area of the field being covered at this height with thin cotton cloth or with laths. Its purposes are (1) to exclude a part of the sunlight, thereby making the leaves thinner and (2) to increase the amount of moisture in the air and the soil, the result of which is a luxuriant and rapid growth. Shade-grown tobacco plants grow tall.

### HARVESTING, CURING, AND PESTS

**449. Indications of maturity.** Tobacco will usually be ready for harvesting in three to three and a half months after the plants are set, or somewhat more than a month after the date of topping. The ripening of tobacco is shown by the following symptoms: (1) The leaves change from a deep green to a lighter shade of green, with a faint tendency

to yellowing or to yellowish mottling. (2) The leaf tends to crumple, especially along the edge. (3) The leaf veins become quite brittle so that, when the leaf is folded between the fingers, a clear distinct break is made. (4) The leaf becomes heavier and somewhat less smooth to the touch.

**450. Harvesting and curing.** The two methods of harvesting are (1) priming, that is, removing the leaves sepa-



Fig. 152. — Tobacco hung in curing barn

rately, and (2) cutting the stalks. In the latter case the stalk is split from the top to near the base and six to ten of the split plants are straddled over a lath, to remain thus while the lath and its load are hanging in the curing barns.

Curing is done, in special tobacco barns, (1) with open flues, (2) by means of flue heat, or (3) by air-curing. These processes are too localized and detailed for description here.

The changes brought about in the curing (Fig. 152) and subsequent fermentation of tobacco are largely the result of chemical ferments or enzymes.

**451. Diseases.** Tobacco is severely injured by wilt, mosaic, and other diseases. Preventive measures consist of

rotation of crops, disinfection of seed beds, and the use of the most resistant varieties.



*Courtesy U. S. Dept. of Agriculture*

**Fig. 153. — Horn worm**

One of the worst enemies of the tobacco plant.

**452. Insect enemies.** The tobacco grower spends much of his time in fighting insects, either by hand work or by poisoning with arsenicals. The most widespread insect enemies are the tobacco worm or horn

worm (Fig. 153) and the budworm, both attacking the leaves, and the cutworm and the wireworm, both of which attack the roots.

### LABORATORY EXERCISES

In high schools located in regions where tobacco is not an important crop, it will usually be advisable to omit this chapter.

The fact that the tobacco plant makes most of its growth during the period of school vacation renders it difficult to arrange for a comprehensive line of exercises on this plant. However, in regions where this is an important crop, it may be practicable for pupils to prepare and plant a small tobacco bed and to participate in the cultural operations connected with the early growth of the young plants.

Seeds of tobacco should be examined and germinated by planting a definite number of seeds by different methods, some on the surface, some in the shallowest possible furrows, and some in furrows about half an inch deep. From the results students should write conclusions as to the best depth for planting seed.

## ADVANCED TOPICS

A. A library study of results of fertilizer experiments on yields and quality.

B. Rotations suitable for tobacco farms and the draft of tobacco on soil fertility.

C. Tobacco breeding.

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## CHAPTER XXV

### HEMP (*Cannabis sativa*)

Hemp is a member of the mulberry family (Moraceæ). It is useful for the fiber, of which burlap bags and twine are made. The plant grows to a height of about ten feet. It is annual, making its growth during the warmest months.

An interesting fact about hemp is that there are male and female plants. The male plants bear in clusters the

flowers containing the stamens, or pollen-bearing parts. On the other, or female, plants are borne the pistils, or seed-producing parts. The male plants are preferred for cultivation.

Each leaf of hemp consists of five to seven leaflets, joined together only at the point where the leaf stem ends (Fig. 154).

The most important hemp-producing district in the United States is the blue-grass region of Kentucky.

#### 453. Soils for hemp.

Hemp is at its best on a rich, moist, limestone soil, but it also thrives on other than lime soils if they are moist, but well drained.

**454. Cultural methods.** The land is plowed flush or "broadcast" and thoroughly harrowed. The seed is sown



Fig. 154. — Leaf and flowers of hemp

a, c, pistillate, or female, flowers;  
b, staminate, or male, flowers.

through a grain drill run in two directions. This insures a more even stand and a more uniform germination and early growth, all of which are desirable in order to secure plants of the desired diameter, preferably half an inch. The quantity of seed required to the acre is one bushel. The date of planting in Kentucky is late in April. No cultivation is given after sowing the seed. Seed originally from China is preferred, though in its first year in the United States it is believed to yield less hemp than during each of the next few years. The small area in Kentucky devoted to hemp grown for seed is planted in checks, with hills about seven feet apart each way, and with four plants in each hill.

The Kentucky Experiment Station found that the use of 160 pounds to the acre of nitrate

of soda and an equal amount of muriate of potash profitably increased the yield of fiber.

**455. Harvesting and preparing hemp for market.** Early in the fall hemp is cut, most of it by hand, but part also



Fig. 155. — A hemp crop in shocks

by special machinery. The stalks are spread evenly on the ground for about a week. Then they are raked together, tied in bundles, and shocked (Fig. 155). The Kentucky Experiment Station found it profitable to stack the hemp, though keeping the hemp in shock saves expense.

Late in November or early in December hemp is retted. This consists in exposing it to cold and rain for about two months, spread out on the ground for the purpose of favoring the separation of the fiber from the adhering materials. When exposure to moisture and to alternate freezing and thawing has effected its end, the hemp is again shocked.

The fiber is separated on the farm chiefly by the old device, called the hand brake. In some regions this work is performed by machinery.

### LABORATORY EXERCISES

(Only for regions where hemp is grown.)

(1) In a field of growing hemp or hemp stubble, count the number of plants that grew on a square yard and estimate the number on an acre.

(2) Make a drawing of a hemp leaf; if fresh or dried hemp flowers can be obtained write a description of both staminate and pistillate flowers.

(3) Using dried hemp plants, separate by hand some of the fiber; write a description of its color, length, position in the plant, etc.

In regions where hemp is not grown, it is scarcely profitable to spend a laboratory period on dried specimens and on the literature of this crop. Instead, this laboratory period may well be devoted to some review or additional exercise relative to the principal crop of the region where the school is located.

### ADVANCED TOPICS

A. A detailed study of the hemp plant.

B. A detailed study of the fiber of hemp and means of detecting the most common textile fibers in manufactured products.

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## CHAPTER XXVI

### THE SORGHUMS (*Sorghum sorghum*<sup>1</sup>)

The sorghums comprise a very interesting group of diverse subspecies grown over a wide range and used for a variety of purposes. Some kinds, or races, are used for the making of sirup and are sometimes erroneously known as "sugar millet"; some are grown for the grain in the top or head; one provides the material from which brooms are made; they all yield forage of different degrees of excellence. The groups belong to the Gramineæ, or grass family.

#### THE SORGHUMS IN GENERAL

**456. Groups of sorghums.** The sorghums may be divided into three groups, all of the same botanical species. These classes are: (1) *saccharine*, or *sweet, sorghums*, grown for forage and sirup; (2) *nonsaccharine*, or *grain, sorghums*, including kafir and milo, the latter being important grain and forage crops in the dry climate of the southwestern part of the United States; (3) *broom corn*, from which brooms and brushes are made.

**457. General description.** The sorghums are giant grasses with stout, solid, pithy stems. The leaves are long and broad, but smaller than those of corn. The heads are of considerable size and varying shape and are borne at the top of the stems. The sorghums have strong root systems, made up of numerous fibrous parts.

All kinds grow slowly during the first few weeks of life, at which time they are easily overrun by weeds; therefore they

<sup>1</sup> Known also as *Andropogon sorghum*, *Sorghum vulgare*, and *Holcus sorghum*.

make their best growth on clean land. The sorghums are generally regarded as the most exhaustive to the soil of the ordinary crops of the farm.

The various sorghums freely cross with each other, the pollen being spread by the wind. The leaves and seeds of all sorghums and the stems of the sweet sorghums are rich in carbohydrates and poor in protein.

**458. Enemies.** In the Southern States, especially from Louisiana eastward, the yield of seed from any class of sorghum is quite uncertain, and complete failures to mature seed are not infrequent. The usual cause of such failures is the attack on the flowers and kernels by a minute insect, the sorghum midge (*Diplosis sorghicola*). For this no effective treatment is known. Very early varieties planted early and heads maturing just before frost suffer least injury.

Sorghum-kernel-smut (*Spacelotheca sorghi*) is a disease caused by a fungus which destroys the individual grains. It is easily prevented by disinfecting the seed as for oat smut (67).

### THE SWEET SORGHUMS

**459. Description and uses.** The sweet sorghums grow eight to twelve feet high and are distinguished from other classes by the great abundance of sweet juice in the stem.

This group is used for the production of sirup as well as of hay and silage, and for feeding green. For sirup, sorghum is most extensively grown in the northern part of the Cotton Belt.

**460. Varieties.** There are many varieties, differing chiefly in earliness, size of stems, form of head, and color of seed and seed covering. The most important are the following:

(1) Amber, an early slender-stemmed variety, having loose black heads (Fig. 156); one variety has red chaff.



Fig. 156. — Amber sorghum

(2) Sumac, or Redtop, medium in maturity, having short very compact heads and small, brownish-red seeds (Fig. 157).

(3) Honey, or Japanese, late in maturity, having large stems and reddish loose heads.

(4) October and Gooseneck varieties, the latter so called because the top of the stem curves; these are large and late, with black heads. For silage the large varieties are favor-

ites; for hay Amber is preferred because of its finer stems.

**461. Soils and fertilizers.** Sweet sorghum may be grown on soils of almost any character. Because of its drought resistance it is often assigned to poorer soil than that given to any other crop outside of the class of legumes or soil-improving plants.

Sorghum is often grown without fertilizer; but on soils where it is necessary to fertilize other crops, this responds profitably to moderate applications of manure and to any commercial fertilizer suitable for corn on the same soil. Nitrogen seems to



Fig. 157. — Sumac sorghum

be the most important constituent in a fertilizer for sorghum, but it is often advisable to add moderate amounts of phosphoric acid and potash. Fertilizer should be applied in the same way as to corn.

**462. Preparation and planting.** Because of the slow growth of the young plants, preparation of the land should be thorough to promote as rapid growth as possible of the young plant and to free the soil from all growing weeds and grass. On well-drained land planting is usually practiced without ridging, which, however, may be necessary on poorly drained bottoms. In the dry climate of the Southwest sorghum is sometimes "listed"; that is, planted in an unfilled furrow, considerably below the level of the field.

A customary distance between rows is  $3\frac{1}{2}$  feet, and between single plants grown for silage or for sirup, 3 to 8 inches. Seeding is performed with a planter, a few quarts sufficing for an acre. For hay 4 to 8 pecks of seed are sown broadcast or in close drills on each acre of rich land; or on medium land 1 to 2 pecks in drills wide enough for cultivation.

When practicable, tillage should be given with a weeder or harrow before the plants appear and again when they are large enough to escape injury. Several cultivations or tillings with one- or two-horse cultivators, and in the Gulf states one or more hoeings, are usually given to sorghum in rows.

Sorghum should be planted several weeks later than the earliest corn. The greater part of the crop is planted in May. However, in the Cotton Belt sorghum for forage



Fig. 158. — Goose-neck sorghum

may be planted as late as July, though such late planting reduces the yield.

**463. Sorghum poisoning.** While sorghum is sometimes grazed by cattle, this involves some risk. Not only may bloat occur, but also sorghum poisoning. Cattle sometimes die suddenly soon after having access to a sorghum field. The cause has been found to be the occasional and probably temporary presence of prussic acid in certain of the plants. While the conditions of its formation are not thoroughly understood, this poison is most likely to be present in young plants grown under stunting conditions, as during drought, or as low-growing sprouts from the old stubble.

No injurious effects result from the feeding of hay or silage from any kind of sorghum, and apparently none from using green sorghum as a soiling plant.

Sorghum is an entirely safe pasturage for hogs, which may graze it from the time it is about two feet high until after it reaches maturity. Sorghum pasturage needs to be supplemented with a grain rich in protein.

**464. Harvesting.** Sorghum intended for sirup is cut with a corn binder, hoes, or cane knives after the juice becomes very sweet and the heads well colored.

To make good silage, sorghum should be fully mature. This plant should usually be mowed for hay when the seeds are in the milk or dough stage. The earlier the cutting, the larger is the second growth. Indeed, by mowing sorghum early on rich land three cuttings are sometimes obtained.

### THE GRAIN SORGHUMS

**465. Adaptation.** There are a number of groups of sorghums grown chiefly for the production of grain. All of these also afford some forage, which is less in amount and poorer in quality than that from the sweet sorghums.

The grain sorghums differ in height, time of maturity, size and shape of head, and color, shape, and size of grain.

The remarkable resistance of the grain sorghums to drought and heat has caused them to be widely grown in place of Indian corn in the Southwestern states. In regions where the rainfall is only 14 to 30 inches they are grown chiefly without irrigation. In such dry climates they yield still more bountifully when irrigated.

Grain sorghums have been still further fitted for the economical use of water and for a hot dry climate by selection. This has been directed chiefly toward dwarfing the stems to a height of  $2\frac{1}{2}$  to 4 feet and toward the production of erect uniform heads, so that harvesting, especially by machinery, may be made easier.

Seed of all the grain sorghums is used as feed for all classes of live stock and is in special demand for poultry. Grain sorghum has usually proved nearly equal to Indian corn in feeding value, but grinding of sorghum grain is more important.

**466. Cultivation of grain sorghums.** In dry farming the ground is plowed as soon as convenient after the winter rains begin, and the surface is kept fine and clean by the repeated use of suitable harrows. Not more than four pounds of seed are planted on an acre in drills about 3 feet apart. Planting is done as soon as the ground has become warm enough, so that the plants may make most of their growth before the moisture from the rains of winter and early spring has been lost. Level planting is customary, but "listing," that is, planting in an unfilled furrow, is practiced in some regions. One plant is desired every 4 to 12 inches in the drill, according to the size of the variety and the probable supply of moisture.

**467. Harvesting.** Varieties of standard height are harvested by corn binders or the heads are cut by hand. Dwarf kinds are harvested with special heading machines or a grain binder, or by hand cutting of the heads. The heads or the entire plants may be threshed or fed as harvested.



Fig. 159. — Head of dwarf milo

Special care is needed to prevent the heating of stored heads and of recently threshed grain.

**468. Milo.** There is a dwarf (Fig. 159) and also a standard milo, both having yellowish, rather large, slightly flattened grains. The heads are large and oval. Milo, also locally, but inappropriately, called "milo maize," is characterized by a tendency for the heads to bend downward, but this has been largely overcome by selection in the case of dwarf milo, which is a favorite in the Texas panhandle region and also in California.

There is a standard white milo, and recently from it has been selected a dwarf white form.

Milo stems are pithy and of inferior value for forage, and the leaves become brown before the seeds mature.

**469. Kafir.** The first grain sorghum to attain great popularity in the United States was kafir (Fig. 160).

In yield of grain kafir proved so much more reliable than corn under the heat and drought of the Southwest that it largely supplanted corn in the western part of Kansas and

Oklahoma. Kafir requires a longer season than does milo and certain other grain sorghums.

The heads of kafir are cylindrical and longer than those of milo and feterita. There are several varieties, including Black-hulled White, Red, Pink, and Dwarf Black-hulled

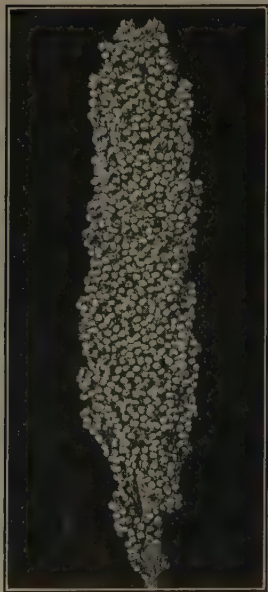


Fig. 160. — Head of Black-hulled white kafir



Fig. 161. — Head of Spur feterita

White. White-seeded varieties are chiefly grown. The leaves of kafir retain their greenness fully up to the time of seed maturity.

**470. Other kinds of grain sorghums.** Spur feterita (Fig. 161) is a selection made by the Texas Experiment Station. It is a dwarf kind and has large, oval, erect heads. The large whitish seed of feterita are characterized by their

bluish tint. By some, feterita is regarded as even more drought-resistant than milo (Fig. 162).

Among a number of other grain sorghums are White Egyptian, or Jerusalem corn, a rather unproductive kind of standard size, with curved heads, and white flattened seeds that easily shatter; and White Yolo, an erect dwarf variety,



Fig. 162. — Black-hulled kafir (left) and dwarf feterita (right)

Showing superior ability of feterita to make a seed crop under conditions of extreme drought.

selected by the California Experiment Station for harvesting by row-heading machines. Darso is an early dwarf kind with reddish brown seeds.

### BROOM CORN

**471. Description.** Broom corn is a tall nonsaccharine sorghum. It is distinguished from other sorghums by the

great length and toughness of the branches that make up the panicle, from which brooms and various kinds of brushes are made (Fig. 163).

A fair yield of cured and prepared brush of the standard varieties is about one third of a ton per acre. The dwarf varieties ordinarily yield about one fifth of a ton of brush per acre, but this dwarf brush commands a higher price. The price of broom corn is subject to violent fluctuations. This is because less than 500,000 acres are required to furnish the entire American crop of broom corn. Therefore an increase of a few thousand acres greatly depresses prices. The chief centers of production are certain districts in Illinois, Kansas, and Oklahoma.

Nashville, Tennessee, is probably the most important Southern market for broom-corn brush. If the crop is grown on farms in the South Atlantic and Gulf states, growers should aim rather to supply local broom factories than to compete on the larger markets with localities in which broom-corn culture is a long-established industry.

Standard broom corn is a tall plant with brush 18 to 24 inches long. Dwarf broom corn usually stands only 4 to 6 feet high and bears brush that is 10 to 18 inches long. From the latter are made whisk brooms, hearth brooms, and brushes. The dwarf varieties are considered to be especially suited to Oklahoma and Kansas.



Fig. 163. —  
Broom corn  
Seeds in detail are  
shown at the right.

**472. Climate, soils, and fertilizers.** While the broom-corn plant can be grown under a wide range of climatic and soil conditions, yet it is most profitable in a climate where there is but little rain at the time of harvest. Any land on which a good yield of corn is ordinarily made is suitable for broom corn.

The same fertilization as for corn, or for sorghum grown for sirup, is advisable. The soil should be fertile enough and the fertilizer rich enough in nitrogen to insure a tall and rapid growth, which is favorable to length of brush.

**473. Cultivation.** Planting in Oklahoma is done chiefly in May. The seed should be planted in well-prepared land in rows about  $3\frac{1}{2}$  feet apart, one plant standing every 3 or 4 inches on rich land or at double this distance on poor land. Cultivation is somewhat more conveniently performed if the plants are left, three to six in a hill, at distances of about 16 inches apart for standard kinds or at shorter intervals for dwarf varieties.

For planting on a seed bed in perfect condition with the expectation of not thinning the plants, 2 quarts of good seed is sufficient for an acre. With land less perfectly prepared or where thinning is necessary, at least double this amount of seed is sometimes used.

Tillage is similar to that given to corn or to sorghum grown for sirup.

**474. Harvesting and preparation for market.** Harvesting of the brush occurs before the seeds form; that is, when the anthers are falling. The heads of the dwarf plants are pulled instead of being cut. Standard varieties must first be bent down, or "tabled." This is done by bending down, about 3 feet above the ground, the stalks on two rows. These bent plants are brought together diagonally in a horizontal position, the brush of one row extending beyond the up-

right portion of the stalks on the adjacent row. The brush is then cut with a sharp knife at a distance of about 8 inches below the head. It is laid, for partial drying, on the tables made by the bending together of two rows of stalks.

After sorting the heads to separate all crooked and un-marketable brush, the immature seeds are removed by scraping or threshing on a special kind of thresher, the brush not passing through the machine, but being held against the revolving cylinders.

Drying is done rapidly in the shade of special sheds and away from strong light, so as to retain the green color. In a shed for curing broom corn the layers of threshed brush are only 2 or 3 inches thick on flat supports, so as to insure ample ventilation and quick curing.

After curing, the brush is packed into bales weighing from 300 to 400 pounds.

### LABORATORY EXERCISES

(1) Write a description of each class and variety of sorghum of which specimens can be obtained, noting especially the following: (a) color of naked seed; (b) color and size of chaff; (c) whether seed is almost completely covered by chaff or projects slightly or is largely uncovered.

(2) Write a description of the heads of each class and variety of sorghum of which specimens can be obtained, noting especially the following: (a) compactness of head; (b) shape of head—oval, cylindrical, roundish, fan-shaped, or irregular—illustrating the shape by drawing the outlines of each head; (c) length of head in inches.

(3) If a field of any class or variety of sorghum can be inspected, make record of the following: (a) the apparent impurity, or percentage of plants which seem to belong in a different class or variety; (b) effects on the size of head and size of stalk due to wide or close spacing of plants.

(4) If a field of kafir or milo can be inspected, note whether there is uniformity in the height of plants and time of ripening. If not, does this diversity interfere with the local method of harvesting the seed?

## ADVANCED TOPICS

A. A laboratory study of the structure of the sorghum head, spikelet, flower, and seed.

B. Practice in identification of varieties of sweet and grain sorghums by the use of the key by Ball, in Piper's *Forage Plants and Their Culture*.

C. Collection of the experience of local farmers in growing sorghums.

D. Judging samples of grain sorghums.

## SCORE CARD FOR GRAIN SORGHUMS

(Adapted from the Texas Score Card)

1. Market condition . . . . .	20
(Free from weather stain, decay, smut, mold, or immaturity.)	
2. Uniformity . . . . .	20
(Among heads in exhibit; or agreement with the standards of the particular variety.)	
3. Arrangement of seed branches . . . . .	20
(Close together and thickly covered with seed; main stem large and continued throughout the head.)	
(a) In <i>standard feterita</i> and <i>kafir</i> seed branches should spring from all sides of main stem at each "joint"; in <i>standard feterita</i> there should be at least 5 joints or whorls of branches, and in <i>kafir</i> at least 6.	
(b) In <i>Spur feterita</i> and in <i>milo</i> branches should be thick on the stem, not arranged in whorls.)	
4. Shape of head . . . . .	10
(Seed branches, especially at base, well filled.)	
(a) In <i>standard feterita</i> the heads should be ovate and about as long as the circumference.	
(b) In <i>Spur feterita</i> the heads should be broadly ovate and shorter than the circumference.	
(c) In <i>milo</i> the heads should be broadly ovate and shorter than the circumference.	
(d) In <i>kafir</i> the heads should be about one and one-half times as long as the circumference, tapering slightly toward the base and tip from the maximum diameter near the middle.	
5. Exsertion of heads . . . . .	5
(Incomplete exsertion, or head not lifted free above the upper leaf sheath, is indicated by unfilled or moldy condition in the lower branches.)	
6. Circumference of heads . . . . .	5
[See 4 (a), 4 (b), 4 (c), and 4 (d).]	

7. Length of heads . . . . . 5  
[See 4 (a), 4 (b), 4 (c), and 4 (d).]
8. Color of kernels and inclosing glumes, or chaff . . . . . 5
  - (a) *Feterita* kernels have a bluish-white tint or a chalklike appearance and are partly inclosed by black glumes.
  - (b) *Yellow milo* has yellowish seed in brown glumes.
  - (c) *White milo* has white seed set in black glumes.
  - (d) The *kafir* varieties generally grown have white or light-colored seed, more slender than milo kernels, and set in black glumes.
9. Size of kernel . . . . . 5  
(Seed should be large for the particular variety, plump, and well matured.)
10. Freedom from shattering . . . . . 5

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# GLOSSARY<sup>1</sup>

## KEY TO PRONUNCIATION

āle, senāte, cāre, ām, āccuse, fārm, tāsks, bānanā; ēve, évent, ěnd, recěnt, farměr; rice, will; hōle, ôbey, sōd, cōrn, cōst, cōrrect; jūte, únite, būrn, cūt, locúst; fōōd, fōōt; about, soil; gig, jig, kick, ink, see, amaze.

**Acid phosphate.** A fertilizer usually containing 16 to 18 per cent of available phosphoric acid; it is made by treating ground rock phosphate with sulfuric acid.

**Alabama argillacea** (ār'jī-lā'shē-ā). The scientific name of the cotton caterpillar.

**Aleurone layer** (ā-lū'rōn). The thin layer just below the seed coats and constituting a part of the endosperm of the seed.

**Amides** (ām'ides—also pronounced ām'ids). Organic compounds, rich in nitrogen, but not serving all the uses of certain other forms of protein.

**Analysis.** Statement of chemical composition.

**Andropogon sorghum** (ān'drō-pō'gōn sōr'gūm). One of the botanical names for all the sorghums, including sweet sorghum, kafir, and milo.  
*See also Holcus.*

**Anthers.** Pollen cases.

**Anthonomus grandis** (ān-thōn'ō-mūs grān'ūfs). The scientific name of the Mexican cotton-boll weevil.

**Anthraxnose** (ān-thrāk'nōs). *See* p. 311.

**Aphids** (ā'phids). Small insects, usually called plant lice, that injure young cotton and other plants.

**Arachis hypogæa** (ār'ā-kīs hī-pō-jē'ā). The botanical name of the peanut plant.

**Ash.** Ashes, or the incombustible mineral residue after burning vegetable or animal matter.

**Auricle.** Clasps, or small projections where leaf blade and leaf sheaf unite.

<sup>1</sup> The pronunciation of technical names as here indicated is based on current usage among American scientists, which follows the English method of pronouncing Latin; the Roman method is sometimes employed.

**Available.** As used regarding plant nutrients, this means capable of being dissolved and appropriated by plant roots.

***Avena sativa*** (ă-vē'nă sâ-tī'vâ). The botanical name of the oat plant.

**Awn.** A beard or bristle, as in the flower of oats or wheat.

**Axil of the leaf.** The angle between the leaf and the stem from which it springs.

**Back-furrowing.** That form of plowing in which successive pairs of furrow slices are thrown toward each other.

**Bacteria.** Minute vegetable organisms, some of which cause certain diseases of plants and animals.

***Bacterium malvacearum*** (băk-tē'ří-ŭm măl-vă'sê-ă'rŭm). The scientific name of the microorganism that causes angular leaf spot and certain other diseases of cotton.

**Bagasse** (bă' găs'). The refuse or crushed stalk of sugar cane or sorghum after the juice is pressed out.

**Bagging.** The common cloth covering around cotton bales.

**Bake.** To form a crust or clod.

**Balk.** A narrow unplowed strip of ground between rows.

**Barring off.** Throwing the earth away from a line of plants by using a turnplow.

**Basic (or slag) phosphate.** A by-product in the manufacture of steel from ores rich in phosphorus. It usually contains about 18 per cent of phosphoric acid, most of it in available form.

***Batatas batatas*** (bă-tă'tăs bă-tă'tăs). The botanical name for the sweet potato plant.

**Beam.** That part of the plow to the front end of which the team is attached.

**Beards.** Long, stiff bristles projecting from the hull of certain seeds.

**Bedding.** The act of so plowing land as to form considerable ridges, or elevated beds.

**Benders.** A commercial term for cotton fiber intermediate in length between short-staple and long-staple lint; so called because it is largely grown on the bottom land in the bends made by rivers.

**Bin.** A tight storage place for threshed grain.

**Binder, or self-binder.** A machine for cutting grain and tying it in bundles.

**Blade.** See leaf blade.

**Bluestone.** See copper sulfate.

**Boll.** The pod within which cotton seed and lint develop.

**Brace roots.** Roots of the corn plant originating at a node above ground.  
*See* p. 82.

**Bracts.** In the cotton plant the three leaflike parts that closely inclose the bud, bloom, or boll.

**Branching wheat.** *See* p. 40.

**Bristles.** Minute hairs, as at the base of a spikelet of oats.

**Broadcast.** Scattered, not sown in drills.

**Budworm.** *See* p. 206.

**Bur** (of cotton). The hull of the open boll.

**Butt.** The end of the corn ear near the point of attachment.

**Calcium sulfate.** A chemical combination of lime and sulfuric acid. Gypsum or land plaster is nearly pure calcium sulfate.

***Calandra oryza*** (ká-lăn'drá ô-rí'zá). The technical name of the black, or rice, weevil, which is very destructive to corn grain.

**Calcium arsenate** (kăl'si-ũm är'sē-nāt). A chemical combination of lime and arsenic.

***Cannabis sativa*** (kăn'á-bĩs sâ-tĩ'vá). The botanical name of the hemp plant.

**Capillary attraction** (kăp'ĩ-lă-rĩ). The force that causes moisture in the soil to move toward the surface or toward the dryer part of the soil; it is now less stressed than formerly.

**Capped.** Covered, as with an extra bundle of grain placed on top of a shock of sheaf grain.

**Carbon dioxide** (kăr'bôn dĩ-ôk'sĩd). Carbonic acid gas; a gas existing in the atmosphere and used by plants. It consists of one part carbon and two parts oxygen.

**Carbon disulphide** (kăr'bôn dĩ-sũl'fid). A liquid which readily turns to a vapor that is fatal to all insect life.

***Ceratocystis fimbriata*** (sěr'á-tô-sĩs'tĩs fĩm'brĩ-ă'tá). The name of the fungus that causes sweet potato black rot, which is designated by some authorities as *Sphæronema fimbriatum* (sfē'rô-nē'mă fĩm'brĩ-ă'tũm).

***Cercospora personata*** (sěr-kôs'pô-ră pěr'sũn-ă'tá). The name of the fungus that causes leaf spot of the peanut plant. *See* p. 332.

**Cereal.** Any edible grain.

**Chaff.** The inclosing portion of the wheat flower that is removed from the grain in threshing; the glumes.

**Cheat.** An annual grass that is a serious weed in fields of wheat and oats.

**Check rower.** A planter by the use of which corn can be planted in checks.

*See* Figs. 65 and 67.

**Chess.** *See* cheat.

**Chinch bug.** An insect attacking corn, wheat, and other plants; it is entirely unlike the household pest of the same name.

**Chit.** The germ or heart of the grain, as in the corn kernel.

**Chrysalis.** The pupal, or changing, stage of certain insects.

***Chloridea obsoleta*** (klō-rīd'ē-ā ōb-sō-lē'tā). The technical name of the corn-ear worm and cotton bollworm. *See* p. 148.

***Claviceps purpurea*** (klāv'ī-sēps pūr-pūr'ē-ā. The name of the microorganism that causes the ergot disease of rye.

**Clasps.** *See* auricle.

**Club wheat.** A class of wheat plants distinguished by the club-shaped head, which is largest at the upper end.

**Cockle.** An annual weed with large pink flowers.

***Colletotrichum gossypii*** (kōl'ē-tōt'rī-kūm gō-sīp'ī-ī). The scientific name of cotton anthracnose, which is the most common form of boll rot.

**Compresses.** Establishments where bales of cotton are again pressed and made denser and smaller.

**Convolvulaceæ** (kōn-vōl'vū-lā'sē-ē). The name of the family to which the sweet potato belongs.

**Copper sulfate.** A chemical combination of copper, sulfur, and oxygen, useful for destroying the germs of many plant diseases.

**Corn binder or harvester.** *See* p. 142.

**Corn stover.** *See* p. 73.

**Cotton, absorbent.** Cotton fiber so prepared by chemicals as to be able to absorb much water. Absorbent cotton is largely used in medicine and surgery.

**Cotton caterpillar.** A caterpillar formerly very destructive to the leaves of cotton; it was often inaccurately called the **army worm**.

**Cottonseed meal.** The meal made from cotton seed after the oil is pressed out.

**Cotton square.** The young bud of the cotton flower with its three surrounding leafy bracts.

**Coulter, rolling.** A revolving disk attached to the beam of a plow in order to cut the soil or the vegetation on it.

**Cowpeas.** A soil-improving forage plant, often called **peas**, or **field peas**.

**Crease.** The depression or furrow on one side of a grain of wheat or rye.

- Crossing.** Hybridizing, or transferring pollen to the stigmas of a different plant, variety, or species.
- Crown.** That part of certain plants, as grains and grasses, from which a number of stems spring.
- Crude fiber.** The woody portion of plants.
- Culms.** Stems or erect branches.
- Current cross.** Immediate hybridization, as shown in the hybrid seeds developed in the same season in which impregnation occurs.
- Cyamopsis tetragonolobus** (sī'á-möp'sís tēt'rá-gŏn'ô-lô'bŭs). The scientific name of the annual summer legume **guar** (gŭ'är).
- Cylas formicarius** (sī'läs fôr'mi-kā'rĭ-ŭs). The scientific name of the sweet potato root borer.
- Delinting.** Removal of part of the fuzz from cotton seed, usually by reginning.
- Delta region.** A region in the western part of Mississippi, consisting of rich river bottom land.
- Diabrotica 12-punctata** (dī'á-brŏt'ĭ-ká 12-pŭnk-tā'tá). The scientific name of the budworm, an insect attacking the stem of very young corn plants.
- Diatræa saccharalis** (dī'á-trē'á sāk'á-rā'lĭs). The technical name for the sugar-cane borer and larger cornstalk borer.
- Dibble.** A small implement or sharpened stick for making holes in the ground.
- Diplodia** (dī-plŏ'dĭ-á). The name of a genus of fungi causing some of the rotting of corn ears.
- Diplosis sorghicola** (dī-plŏ'sís sŏr'gĭ-cŏ'lá). The scientific name of the minute insect which destroys the seeds of the sorghums and which is largely responsible for the failure of the crop of sorghum seed in the humid regions of the South.
- Disinfection.** Destruction of the germs of disease, usually by treatment with chemicals or with heat.
- Disked.** Tilled with a dish plow or disk harrow.
- Disk harrow.** A harrow consisting of a number of circular concave disks.
- Disk plow.** A plow in which the work of cutting and inverting the soil is done by a large, concave, circular dish which revolves.
- Dominant quality.** That one of a pair of contrasted qualities which shows in the larger proportion of the offspring.
- Double fertilization.** That process occurring in the impregnation of some plants by which the pollen influences not only the germ of the seed, but also the endosperm.

**Dough stage.** The stage of a maturing grain when the seed is in the stage of firmness represented by dough.

**Ducts.** The channels through which the crude sap of plants circulates.

**Einkorn.** The German word for one grain; the name of one kind of wheat.

**Elementary species.** Groups of similar plants; often subdivisions of what has generally been assumed to be one variety.

**Emasculation** (of flowers, Fig. 104). Removal of the stamens before maturity of the contained pollen.

**Embryo.** The germ of the seed or grain.

**Embryo sac.** A part of the ovary which incloses the female germ cell.

**Endosperm.** The part of the grain or seed around the germ.

**Entomologists.** Persons skilled in the knowledge of insects.

**Environment** (of plants). Surrounding conditions, for example, soil, rainfall, fertilizer, distance between plants.

**Fertilization of corn grain.** The act or fact of union of the male and female elements; the usual result of pollination.

**Fibrous-rooted.** Having numerous fine roots without a taproot.

**Firing.** The premature drying of leaves on growing plants.

**Flaxseed.** The name given to the pupal stage of the Hessian fly.

**Floret.** A flower.

**Flush plowing, or flushing.** Plowing land without forming ridges or deep depressions; "broadcast" plowing.

**Fodder.** A term often applied in the South to corn blades or leaves.

**Forage.** Coarse food for live stock; forage plants are those that afford pasturage, hay, etc.

**Forceps.** Pincers.

**Formaldehyde** (fôr-măl'dê-hîd). A pungent gas destructive to microorganisms or disease germs. Its usual form is a 37 per cent solution in water, from which it readily vaporizes. This solution is also popularly called formaldehyde, or **formalin**.

**Formalin** (fôr'mă-lîn). *See formaldehyde.*

**Forms.** A term used to designate either the bud squares, blooms, or bolls of the cotton plant.

**Garlic, wild.** Crow garlic, or wild onions, a troublesome weed.

**Germ.** A word popularly used both (1) for microorganisms and (2) for the embryo of seeds.

**Germination.** The act of sprouting, as with seed.

**Germinator.** A box or other device in which seeds are sprouted to determine the proportion of seeds able to grow. *See* p. 103.

**Ginnery.** The building, including the equipment, in which cotton is ginned.

**Glomerella gossypii** (glŏm-ēr-ĕl'á gŏ-sĭp'ĭ-ī). The name of the fungus that causes cotton anthracnose.

**Glucose.** A noncrystallizable form of sugar.

**Gluten.** A nitrogenous constituent which is largely responsible for the toughness or rising quality of dough made from wheat flour.

**Gossypium** (gŏ-sĭp'ĭ-ŭm). The botanical name of the genus that includes all kinds of wild and cultivated cotton plants. *See* p. 190.

**Glumes.** The chaffy parts, or bracts, usually in pairs, around a spikelet or seed of grain or grass.

**Grain drills.** Implements for sowing grain and other seed in narrow drills.

**Grain moths.** Several small moths, the larvæ of which attack wheat, corn, and other grain.

**Gramineæ** (grá-mĭn'ĕ-ē). The botanical name of the grass family.

**Guar** (gū'är). *See* *Cyamopsis tetragonolobus*.

**Head rice.** Prepared rice of the highest grade.

**Heaving.** Lifting of plants and soil as the result of freezing of the soil.

**Heel scrape.** An implement for shallow cultivation. *See* Fig. 112, where a heel scrape is attached to a plow stock.

**Hessian fly.** A small insect which lays its egg on the stems of grain plants, later causing weakness or falling. *See* pp. 35 and 36.

**Heterodera radicola** (hĕt'ēr-ŏd'ĕ-rá răd'ĭ-sĭk'ŏ-lá). The scientific name of the minute garden nematode worm that causes root knot of cotton, legumes, and many other plants.

**Hoe drill.** A grain drill whose opening device consists of plowlike parts.

**Holcus sorghum** (hŏl'kŭs sŏr'gŭm). The technical name for all kinds of sorghum—a name recently used by some botanists for *Andropogon sorghum*, which was formerly employed. *See* p. 404.

**Hopper-dozers.** Devices to be pulled through fields for catching grasshoppers. An essential feature is a vertical cloth, which the flying grasshoppers strike. They then fall into a large pan containing kerosene, which kills them.

**Hulls, oat.** The parts of the oat grain which tightly enfold the kernel.

**Humus.** Partly decayed vegetable or animal matter in the soil.

**Hybridized.** Crossed.

**Hydrochloric acid** (hī'drō-klō'rīk). A corrosive acid consisting of hydrogen and chlorine.

**Impregnation.** *See fertilization* of corn flowers (p. 64).

**Internodes.** That part of a stem lying between two nodes or joints.

**Intertillage.** Cultivation among growing plants.

**Invertase** (in'vēr-tās'). An organic chemical that prevents the crystallization or "turning to sugar" of syrup.

**Johnson grass.** A perennial grass, difficult to eradicate.

**Kernel.** In common usage, a grain or seed.

**Kiln.** A term usually applied to a house or room in which some article is to be dried by artificial heat.

**Lady beetle.** *See ladybug.*

**Ladybug.** One of a group of small beetles, which prey on harmful insects.

**Land plaster.** An impure form of sulfate of lime. It is sometimes bought as a fertilizer; it is also obtained free as a necessary filler in acid phosphate, about half the weight of which consists of land plaster.

**Larva** (plural, *larvæ*). The grub, or caterpillar, stage of any insect; this is the stage in which most insects feed most ravenously and in which they make most of their growth.

**Leaching.** The dissolving of plant food in the water of the soil and its removal in the water that drains away.

**Leaf blade.** The expanded part of a leaf.

**Leaf sheath.** *See sheath.*

**Leaf stem.** The stalk which supports the expanded part of a leaf.

**Leaflets.** The separate, complete, leaflike parts that make up what is botanically a leaf of locust, pecan, etc.

**Legume** (lē'ūm or lē-gūm'). A plant bearing a pod; the legumes in common use in agriculture, such as cowpeas, clovers, etc., are chiefly valuable because the enlargements (tubercles or nodules) on their roots store up nitrogen from the air for the enrichment of the soil. Moreover, most cultivated legumes are valuable forage plants.

**Leguminosæ** (lē-gū'mī-nō'sē). The botanical name of a large group of plants that includes the smaller family **Papilionaceæ**, which see.

**Leguminous plants.** *See legume.*

- Lemma** (lēm'ă). The larger hull or chaffy part (glume) inclosing a seed of grain or grass.
- Lint.** The word commonly used to designate the fiber of cotton.
- Linters.** The very short lint removed from cotton seed subsequent to ginning; the removal of linters is usually done at the cotton-oil mills.
- Lissorhoptrus simplex** (līs'ô-rôp'trūs sīm'plĕx). The scientific name of the water weevil, which injures rice plants.
- List.** A small ridge formed by throwing two furrow slices together.
- Lister.** A double moldboard plow used in the Southwest for opening a deep furrow in which to plant crops.
- Lock of cotton.** The seed and attached lint contained in one division or compartment of a boll of cotton.
- Lodge.** To fall down, as nearly mature plants of oats.
- Lubricant.** A substance used to oil machinery to reduce friction.
- Macaroni wheat.** A class of hard or durum wheats, from which is manufactured the human food macaroni.
- Maize.** Another name for corn.
- Malvaceæ** (māl-vā'sĕ-ē). The scientific name of the mallow family, which includes cotton, okra, etc.
- Marisnius saccharali** (mă-rīs'mī-ŭs sāk'ă-rā'līs). The name of the fungus causing root rot of sugar cane.
- Mating area.** A tract of land on which two or more valuable strains, as of corn, are planted in adjacent rows for the purpose of effecting cross-pollination.
- Maturity.** Ripeness.
- Melilotus alba** (mĕl'ī-lō'tŭs ăl'bă). From three Latin words meaning respectively, honey, plant, and white. *See* **sweet clover**.
- Mendel's law.** A principle discovered by Mendel which explains the mathematical proportions in which certain qualities are inherited by hybrid plants or animals.
- Middle burster** (or **breaker**). A plow with both a right-hand and a left-hand moldboard, thus at the same time throwing the soil both to right and left.
- Middling.** A certain commercial grade of cotton.
- Midge.** A particular insect of small size. For the **sorghum midge**, *see* p. 405.
- Milk stage.** The stage of ripeness of a grain in which the contents of the seed are of the consistence and color of milk.

**Mosaic disease** (mô-zā'ík). *See* p. 363.

**Mower.** A mowing machine.

**Mulch.** A covering, usually of loose soil or litter.

**Multiplication plot.** An area of some crop grown chiefly with a view to increasing the amount of good seed for planting, without special reference to improvement in the quality of the seed. *See* p. 101.

**Muriate of potash** (mū'rī-āt, pōt'āsh). A saltlike fertilizer containing about 50 per cent of potash.

**Nematode worms** (něm'ā-tōd). Minute worms which enter the roots of certain plants and cause harmful enlargements.

**Neocosmospora vasinfecta** (ně'ō-kōz-mōs'pō-rā vās'yn-fēc'tá). The scientific name of cotton wilt or black root.

**Nicotiana tabacum** (nī-kō'shī-ā'ná táb'ā-kūm). The botanical name of the tobacco plant.

**Nitrate of soda.** A combination of sodium and nitric acid forming a soluble and prompt fertilizer containing 14 to 16 per cent of nitrogen.

**Nitrogen.** A chemical element which in certain combinations is an important fertilizing material and in other forms a valuable part of the food of man and lower animals.

**Nitrification.** The process by which the nitrogen, as in decaying plants changes into the available form of nitrate by combining with oxygen. This change is caused by microorganisms.

**Nitrogen-free extract.** In plants nutritive compounds containing no nitrogen and consisting chiefly of starch, sugar, etc.

**Node.** A joint on a stem where a leaf is usually borne.

**Nonsaccharine** (nōn-sāk'ā-rīn). Not containing appreciable amounts of sugar.

**Nucleus** (nū'klē-ūs). An extremely small particle of living matter, constituting the most important part of a plant cell.

**Oryza sativa** (ō-rī'zā sá-tī'vá). The scientific name of the rice plant.

**Oxygen.** A gas existing in the atmosphere and required in some form by all forms of life. Oxygen also exists in combination with numerous elements, forming gases, liquids, and solids.

**Palet or palea** (pǎ'lět, pǎ'lē-ā). The smaller and thinner of the two chaffy parts or bracts that immediately inclose a seed of grain or grass.

**Papilionaceæ** (pá-pīl'ī-ō-nā'sē-ē). The name of the family to which peanuts, clovers, and most other cultivated legumes belong.

- Parasite.** An animal (or vegetable) organism which lives on and obtains nourishment from the body of another.
- Pectinophora gossypiella*** (pĕk-tī-nô'fô-râ gō-sĭp'ī-ĕl'lâ). The scientific name of the pink bollworm of cotton.
- Peduncle** (pĕ-dŭnk'ŭl). In the cotton plant, the stem supporting the square, bloom, or boll.
- Peppergrass.** An annual weed of the mustard family, seeding about the same time as wheat.
- Petal.** A division of the floral parts, usually colored, that encircle the stamens.
- Phosphatic.** Containing a large proportion of phosphorus or phosphoric acid.
- Phosphoric acid** (fôs-fôr'ĭk). The chemical compound of the elements phosphorus and oxygen that makes acid phosphate a valuable fertilizer.
- Phymatotrichum omnivorum*** (fĭ'mă-tô'trĭ-kŭm ōm-nĭ-vō'rŭm. The scientific name of the organism causing cotton-root rot.
- Piedmont section.** The elevated country at the eastern base of the Appalachian Highlands.
- Pima** (pĕ'mă). The name of a variety of Egyptian cotton grown in California and Arizona.
- Pine needles.** Pine leaves.
- Pistil.** The central portion of a flower at the base of which seed may develop.
- Polish wheat.** See p. 28.
- Pollen.** The male element in the fertilization of a flower; usually dust-like or in the form of minute particles.
- Pollen tube.** A slender outgrowth from the pollen grain after the latter finds lodgment on a receptive stigma.
- Pollination.** The act or fact of conveying pollen to the receptive stigma.
- Pores.** Openings.
- Potash.** The compound of the chemical elements potassium and oxygen that makes **kainit** a valuable fertilizer.
- Protein** (prō'tē-ĭn). Certain compounds rich in nitrogen, found in plants and animals.
- Puccinia rubigo-vera* and *Puccinia graminis*** (pŭk-sĭn'ī-â rōō'bĭ-gō-vē'râ, grăm'ī-nĭs). The names of the microorganisms that cause the two most common rusts of the small grains.
- Pupa** (plural, pupæ). See pupal stage.

- Pupal stage.** That stage in the life of most insects which follows the larval, or "caterpillar," or "grub," stage and which immediately precedes the stage of the mature insect. The pupal stage is not usually a period of growth, but of inactivity and of change of form.
- Quarter drains.** Shallow cross-drains in a field of sugar cane.
- Rachis** (rā'kīs). The portion of the stem on which flowers and seeds are borne.
- Raw phosphate.** See p. 232.
- Recessive quality.** That one of a pair of contrasting qualities that appears in the smaller proportion in the hybrid offspring.
- Red clover.** Commonly called clover; a biennial forage plant with roundish, pinkish flower heads.
- Rhizoctonia** (rī'zōk-tō'nī-ā). The scientific name of the damping-off or sore-shin disease of young cotton plants.
- Rice bran.** See p. 155.
- Rice polish.** See p. 155.
- Rice weevil.** Though named for the rice plant, this weevil does most injury to stored corn.
- Rick.** A long stack.
- Ridging.** See bedding.
- Rotation of crops.** The succession of crops that follow each other on the same field in regular order.
- Rust.** Diseases of certain plants due to the presence of definite, minute, vegetable organisms.
- Score card.** A numerical standard of excellence.
- Screening.** Separating by means of sieves.
- Sea-island cotton.** The plant that produces the longest, finest cotton fiber; its name is taken from the fact that this species of cotton is grown chiefly on islands along the South Atlantic seacoast.
- Saccharum officinarum** (sāk'ā-rūm ō-fīsh'ī-nā'rūm). The botanical name of sugar cane.
- Saccharine** (sāk'ā-rīn). Containing sugar, as the stems of the sweet sorghums.
- Secale cereale** (sē-kā'lē sē'rē-ā'lē). The botanical name of the rye plant.
- Self-pollination.** Conveyance of pollen to the pistil of the same plant. Oats and wheat are self-pollinated.

- Sepal.** A division of the floral parts, usually not brightly colored, encircling the base of the colored portion of the flower.
- Shank.** In the corn plant, the support for the ear.
- Shatter.** To drop the grains prematurely.
- Sheaf oats.** Oat plants not threshed, including grain and straw.
- Sheath.** The lower or stem-encircling part of the leaves of grasslike plants.
- Shock.** A collection of bundles of grain plants leaning together; a small pile of hay.
- Shocker.** See p. 140.
- Shoe drill.** A grain drill whose openers consist of pairs of vertical sheets of metal joined at the front and becoming farther apart at the rear.
- Shredder.** A machine for tearing into small pieces the coarse stems and other parts of cornstalks and other forms of coarse forage.
- Shucks.** Corn shucks, the leaflike parts inclosing the ear.
- Sieve tubes.** Plant structures for the circulation of sap.
- Silo.** See Fig. 36 and p. 74.
- Slips.** The slips of the sweet potato are also called *sets* and *draws*. They consist of the young shoots growing out of the potato that is bedded.
- Small grains.** A term applied collectively to wheat, oats, rye, and barley in distinction from the larger grain, corn.
- Smut.** A disease of certain plants due to the growth of certain minute vegetable organisms.
- Sorghum vulgare** (sôr'gũm vŭl-gā'rê). The scientific name which is used by some authorities to include all the sorghums. See *Andropogon sorghum*.
- Species.** A group of plants having certain qualities in common.
- Sphacelotheca sorghi** (sfäs'ê-lô-thê'kâ sôr'gî). The scientific name of the fungus causing the kernel smut of the sorghums. See p. 233.
- Sphæronema fimbriatum.** See *Ceratocystis fimbriata*.
- Spike.** A spike in plants means an elongated head, as in wheat, rye, and barley.
- Spikelets.** A small cluster of flowers or seeds.
- Spores.** Minute bodies which serve the purpose of seed for the fungi that cause most plant diseases.
- Square.** The earliest form of the floral buds of cotton; so named because of the angular figure formed by the three leafy bracts surrounding the immature flower.
- Stamens.** Anthers or pollen cases together with their supports.

- Sterility.** In plants, failure to produce a normal number of seed.
- Stigma.** The upper part of the pistil on which pollen must lodge and grow to effect fertilization of the flower.
- Stomata** (stō'má-tá). Minute openings in the outer layer of plant tissue, especially on the under sides of leaves, through which openings the leaf gives off moisture and takes in carbon dioxide gas and oxygen.
- Strains.** Subdivisions of a variety.
- Subsoil plow.** A plow for loosening without inverting the soil.
- Subsoiling.** See p. 126.
- Subspecies.** A division of a species.
- Suckers.** In the corn plant, stems springing from some of the lower nodes of the main stem.
- Sucrose.** Crystallizable sugar.
- Sulfate of potash** (sül'fāt, pöt'āsh). A fertilizer containing 37 to 50 per cent of potash.
- Sulfuric acid** (sül-fū'ric). A corrosive acid containing sulfur and used in the manufacture of acid phosphate.
- Sweep.** A cultivating device consisting of two wings and of a deeper central part, by which latter it is attached to a plow stock. See detached implement in Fig. 112.
- Sweet clover** (*Melilotus alba*). A biennial, summer-growing legume valuable for soil improvement, pasturage, and hay for home use.
- Tankage.** A dried by-product of slaughterhouses, which is rich in nitrogen and ash.
- Taproot.** The main central root of such plants as cotton.
- Tare.** The allowance for weight of the covering, or bagging and ties, on a cotton bale; in practice it is usually 24 pounds or less in American markets.
- Tassel.** The panicle of male flowers borne at the top of a flowering corn plant.
- Teosinte** (tē'ō-sin'tē). A tropical forage plant, closely related to corn.
- Tetranychus telurius** (tēt-rān'ī-kŭs tē-lŭ'ri-ŭs). The scientific name of the red spider, a small mite which attacks cotton leaves.
- Threshing.** The act of separating the grains of wheat, oats, etc. from the straw and chaff.
- Tillage.** Cultivation.
- Tiller.** To branch from the crown; to stool.
- Tip.** The end of a corn ear farthest from the point of attachment.

**Toxic.** Poisonous.

**Transpiration.** The loss of water from plants by its passing into the air from the leaves, etc.

**Triticum** (trīt'ī-kūm). The name of the genus to which the several species of wheat belong.

**Triticum aestivum** (trīt'ī-kūm ēs'tī-vūm). The botanical name of common or bread wheat, though other terms are sometimes employed to designate this species.

**Turnplow.** The kind of plow most generally used for turning over the soil. It includes a concave moldboard for twisting, pulverizing, and inverting the furrow slice.

**Ustilago maydis** (ūs'tī-lā'gō mā'dīs). The name of the fungus causing corn smut.

**Ustilago avenae** (á-vē'nē). The name of the microörganism that causes the common smut of oats.

**Ustilago hordei** (hôr'dē-ī). The name of the fungus causing the covered smut of barley.

**Ustilago nuda** (nū'dá). The name of the fungus causing the naked or conspicuous smut of barley.

**Ustilago tritici** (trīt'ī-sī). The name of the fungus causing the loose or conspicuous smut of wheat.

**Utility score card.** A standard for judging corn ears which takes note chiefly of useful characteristics.

**Variety.** A subdivision of a species; a group of individual plants possessing in common certain botanical or agricultural characteristics.

**Vegetable matter.** Material now or recently existing in the form of plant tissue.

**Vegetative branches or limbs.** On the cotton plant, those branches to which no bolls are directly attached (see p. 168); common equivalent terms are *base limbs* and *suckers*.

**Vermicelli.** A form of macaroni, manufactured from wheat.

**Vetch, hairy.** A winter-growing, annual, leguminous plant, suitable for soil improvement, pasturage, and hay.

**Vine cuttings.** Sections of vines cut off and planted, as with sweet potatoes.

**Vitality.** In seed, ability to sprout and to produce strong young plants.

**Vs., versus.** Against, or in comparison with.

**Water furrows.** The depressions or shallow trenches between two elevated beds of soil.

**Weeder.** A form of light harrow with long, flexible teeth.

**Whorls.** Sets or groups.

**Wild onion.** *See* garlic.

**Windrows.** In sugar-cane culture this applies to the rows of heaped and covered cane intended for planting.

**Winter killing.** The dying of young plants from cold or heaving.

***Zea mays*** (zē'ā māz). The botanical name of the Indian corn plant.

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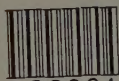
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